Information and communication technologies and the integration of financial marketplaces: the development of the Euroclear Single Platform for cross-border securities settlement

Nikiforos S. Panourgias
Information Systems and Innovation Group
Department of Management
London School of Economics and Political Science

Thesis submitted to the Information Systems and Innovation Group of the Department of Management, London School of Economics and Political Science for the degree of Doctor of Philosophy, London, October 2007.

ProQuest LLC
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106-1346

Declaration

I certify that the thesis I have presented for examination for the MPhil/PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

Signed: S.N.S. Panourgias Date: 15/7/2008

Abstract

While cross-border financial activity continues to grow, facilitated by the adoption of electronic information and communication technologies (ICTs) and the multi-jurisdictional presence of large financial corporations, securities marketplaces have remained locally organised. Why has marketplace integration in this area lagged when ICTs have made possible the linking of geographically remote transacting parties and enhanced their calculative capabilities? This question raises issues regarding distinctions between markets and marketplaces and the implication of ICTs in the constitution of financial marketplaces that this research seeks to address through a study of an initiative to use ICTs to integrate the securities marketplaces of the UK and Ireland, France, Belgium, Holland, and Brussels-based international central securities depository Euroclear Bank. Adopting an approach informed by the social studies of finance that emphasise the importance of technologies, systematic knowledge, and material practices in the functioning of financial markets, the central empirical focus of the research is to trace the articulation of human and non-human entities involved in the development of the Euroclear cross-marketplace securities settlement platform. The study shows that integrating securities marketplaces is far from being a neat technical process requiring the integration of ICT systems. Instead, a meticulous sociotechnical re-articulation of the exchange architectures that format the encounters between transacting parties and transacting parties and objects of exchange is required. Furthermore, as the new arrangements take shape, they become a concrete interrogation of the world – both conceptual and material – surrounding them; technical issues become part of wider controversies, with points of interface between the emerging system and other sociotechnical networks it comes into contact with becoming nodes of actions, questions, and reactions from agencies required to respond to the demands of the new platform from the world around it. In the process, competing inscriptions of assumptions about the world are rendered explicit and contestable as the experiment of ICT-inspired marketplace integration becomes embroiled in a trial of rival conceptions of politico-economic integration.

Acknowledgements

First of all, I would like to thank my two supervisors, Dr. Susan Scott and Professor Jannis Kallinikos. Working with Susan on the Moving Markets project provided the inspiration and put in place some of the foundations for this research project. Because of the particular pressures and practicalities of embarking on a thesis and having to participate in caring for a newborn daughter, her pragmatic and unfussy approach to supervising this thesis was crucial to its completion. Jannis, especially in the early stages of the dissertation when so many of the key conceptual and methodological choices that underpin such a research project need to be made, also provided invaluable help in putting in place some solid foundations for the dissertation. Admonitions such as "what assumptions are you making about reality", "don't treat technology as an epiphenomenon", and "does IT matter" where a constant reminder throughout the project of the importance of not loosing sight of the bigger picture. Whether critical or supportive, inputs from the entire Information Systems and Innovation Group, from fellow students as well as staff, have contributed to this work and I am grateful for that. In particular, I would like to thank Dr. Nathalie Mitev and Professor Ole Hanseth, for their useful, detailed, and supportive comments in the first year upgrade.

I would like to say a special "thank you" to Fabian Muniesa for his encouragement and advice throughout the project, especially when the going got tough. His suggestions were invariably spot on as were his recommendations regarding relevant readings. He has been an invaluable, but also rigorous, guide to the subtle but fundamental nuances of actor network theory, the social studies of finance, and economic sociology.

This research project would have been substantially curtailed, both in terms of its scope as well as potential insights, without the support of Euroclear in terms of providing access to the organisation and granting a licensing for the use of their documentation in the thesis. In particular I would like to thank Kevin Wooldridge at the Business Model and Harmonisation Division for his help, patience, and inputs. I am also very grateful to Pen Kent, who, through his unsurpassable experience and inside knowledge of the settlement business in general and the dematerialisation of securities in the UK in particular provided invaluable information for this thesis, both in terms of historical background but also on-going developments and controversies. His comments, clarifications, explanations, and engagement during the writing of the thesis were also very much appreciated.

Last but not least, I would like to thank my parents, for instilling in me, from an early age, an interest in enquiry, study, and debate and providing me with the education to pursue this interest, and the rest of my family for their unstinting support and tolerance during what has often been a fraught time in terms of the impact of such an undertaking on normal family life. In particular I owe a huge amount of gratitude to my wife Paola who, through thick and

thin, has believed in my project, despite having to carry, for its duration, a disproportionate burden in terms of the material and emotional needs of our household. Finally, I would like to acknowledge the inspiration provided by my daughter Sofia, who was born just before the commencement of this thesis and whose imminent arrival became a catalyst in deciding to embark on this undertaking.

This research has been funded through an EPSRC studentship and, in the first year, by a one-off Bursary for the study of Information Systems instituted by Royal Dutch Shell.

Table of Content

List of Figures

List of Tables

Introduction

The growth of cross-border economic activity, the development and adoption of a range of electronic information and communication technologies that make possible low-cost and fast remote commercial interactions, and the use of increasingly complex financial instruments composed of an ever-expanding range of underlying financial assets, are driving financial services firms to become increasingly global in both scope and reach[1]. These developments, however, are constricted by the lack of the necessary market arrangements needed to make possible the seamless, secure, and incontestable conclusion of transactions across asset categories and jurisdictions (Group of Thirty 2003, de Carvalho 2004).

In Europe, apart from the general trends outlined above that are motivating demands for the development of cross-border financial market structures, there are additional pressures in this direction from the process of political and economic integration associated with the establishment of the European Union (EU). Following the adoption of the Euro, there has been an intensification of such initiatives, with a number of explicit public policy interventions aiming to encourage the establishment of a single pan-European market for, among other financial instruments, securities[2]

The following vivid account, written in 1990, of how a future global financial marketplace might result out of these pressures and what this global marketplace might look like, is provided by the Chairman and CEO of the Chicago Board Options Exchange (CBOE) at the time, Alger Chapman.

> "The pace of change is increasing so rapidly that it is not unreasonable to imagine a highly sophisticated international marketplace where everything is traded but nothing is listed: an institutional marketplace

[1] A detailed presentation and discussion of the data that point to this growth in cross-border economic activity and a parallel growth in cross-border financial services and transactions can be found in (Berger, DeYoung, Genay and Udell 1999). See also (Sassen 2005).
[2] Examples include the Giovannini reports (Giovannini Group 2001, 2003), the Lamfalussy reports, the Lisbon Agenda, and the Settlement Finality Directive.

> linked by a sophisticated satellite transmission network, in which institutional traders communicate modem to modem, and bids and offers are taken by touching a screen to produce a locked-in trade, with price and volume information disseminated to all participants. In this hypothetical marketplace, trades are cleared and settled by a "WorldClear" system which links to existing clearinghouses electronically for national markets, and to Cedel and Euroclear. Daily net balances are reached for each participant, and then consolidated in the WorldClear system where money balances are settled and the transfer of financial instruments is accomplish by bookkeeping entry only."[3]

While more than a decade and a half has passed since that account, at present the scope and reach of the global financial system, such as it is, is still coming up against many legal, regulatory, organisational, and technological structures that are still predominantly nationally organised. This is especially true regarding the trading of securities (e.g. stocks and shares, corporate and government bonds), reflecting the specific and historically shaped institutional, organisational, and technological arrangements that govern their trading [4]. In Chapman's vision of the future of financial markets, the role of such national arrangements was at best marginal, as the following passage shows:

> "National markets [will] operate on the periphery of this hypothetical global system. Instruments of local interest trade just like [in] current home markets in government securities, and corporate bonds and stocks. Home country securities with international interest trade in both the home and global markets. This global market [will be] dominated by several dozen international trading organizations, banks, and investment firms with billions of dollars of capital, and a trading rather than an agency business. In all probability, they [will] also dominate major national markets. An examination of the Eurobond and Forex markets gives us a real-world preview of the developing electronic global market. These markets are institutional, dominated by big, well-capitalized participants trading around the clock and operating with limited national government regulation."[5]

The view expressed in the above account is indicative of a widely held assumption, found in many academic and non-academic analyses, that financial activities, enabled by the growing reach, scope, affordability, availability and power of electronic information and communication technologies (ICTs) are at the forefront of so-called processes of globalisation through which local and

[3] In (Chapman 1990, p.198)
[4] See (Giovannini Group 2001, Pirrong 2002).
[5] In (Chapman 1990, p.198)

particular market arrangements are being subsumed effortlessly, through the employment of ICTs, into new and global in scope and logic arrangements[6]. This assumption is underpinned by a view of financial transactions – and the marketplaces these take place in – as increasingly frictionless and dematerialised, with markets brought into existence almost at will – as if by magic – through the simple linking of previously spatially separated transacting parties using ICTs, "leaving money obligations to speed their way along the cables and through the aether, to and from many different terminals located in many different places" (Thrift 1994a, p.327) [7].

The reality on the ground, however, is that the global organisation of the financial services industry is still in a situation of tension between the need for transactional arrangements that transcend geographic and jurisdictional boundaries and financial marketplaces and exchange venues that remain jurisdictionally circumscribed (Group of Thirty 1988, Lee 1998, Giovannini Group 2001, Group of Thirty 2003, de Carvalho 2004). This tension is an indication of the durability of these local marketplace arrangements, gained over time through the intertwining of the institutions, rules, norms, practices, networks of market participants, and technologies that characterise particular trading venues (Duguid 1901, Kynaston 1983, Williams 1986, Blakey 1993, Shearlock and Ellington 1994, Smith 1996, Currie 1997, Moser 1998, Michie 1999, Moser 1999). The durability and stubborn persistence of these concrete

[6] For an account of some of these positions see (Cerny 1994). Thrift (Thrift 1994b, 1994a) also presents and then challenges a number of positions that assume "that international financial centres will become redundant in a world where electronic flows of information predominate" and in which "the very idea that financial markets need a geographic centre is being gradually refuted by electronics" (Thrift 1994b, p.300). For a more general critique of "the bluster and hyperbole of the epic and epochal accounts which are now almost automatically associated with writing on the new electronic telecommunications technologies", see (Thrift 1996).

[7] The currency, or foreign exchange (FX), markets are often held up as concrete examples of such "genuinely global markets" that behave as "collective disembodied systems generated entirely in a symbolic space" (Knorr-Cetina 2005). Even if "traders in interbank currency dealing" do "trade for their banks' accounts via direct dealer-to-dealer contact or via electronic brokerage systems disengaged from local settings" (Knorr-Cetina 2005), there are always complex but usually obscured concatenations of contractual relations that, if traced, lead ultimately to transactions on marketplaces that need to be settled. While the claim that the "trading in currencies and securities is instant thanks to vast computer networks" (Sassen 2005, p.22) might be true with regard to the agreement on the terms of such an exchange, the settlement of these trades is not usually instant. Even with a purely domestic trade, the settlement of securities transactions can take days and can take significantly longer in cross-border cases.

marketplace arrangements point towards a more complex – and complicated – view of the relationship between ICTs, markets, and marketplaces than the one sketched by Chapman.

Despite the emergence of what could be considered as a nascent global financial system, the issue of cross-border financial marketplace integration and the related questions of how such integration can be achieved in practice and what the role of ICTs in such processes might be, remain largely unresolved (Group of Thirty 1988, 2003). While it is intended that more complete answers to such questions should emerge out of the research, it is clear that beyond the putting in place of ICT-based linkages between previously separate transacting parties involving electronic data networks, message sets, databases, and computer systems, financial marketplace integration also entails the reconciliation and accommodation of disparate legal regimes, competitive landscapes, public policies, meanings, understandings, and definitions involved in the organisation of transactions and built into the various existing local marketplace technologies over time.

Crucially, while some of the elements of Chapman's vision can be discerned, one key central component that is missing, but which is a make-or-break dependency for such a vision of a global financial marketplace (Group of Thirty 1988, 2003), is the entity Chapman refers to as "WorldClear" where trades are cleared and settled, daily net balances for each participant are calculated and then consolidated in the WorldClear system "where money balances are settled and the transfer of financial instruments is accomplish by bookkeeping entry only" (Chapman 1990, p.198).

Clearing and settlement systems are core components of financial marketplaces. Furthermore, as Thrift points out in a historical account of the constitution of the City of London as an international financial centre, "the walks and rounds" associated with "the need to intermesh time and space in various settlement systems", act as "a kind of socio-spatial glue" that contributed to defining financial centres and the markets that comprise them as places (Thrift 1994b, pp.322, 316, 322).

No market transaction is complete without the mutual obligations entered into by the transacting parties being discharged through the reciprocal movement of the objects being exchanged, from the world of one party to that of the other (Slater 2002, Callon and Muniesa 2005, Millo, Muniesa, Panourgias and Scott 2005). Any financial marketplace integration initiative will depend on developing appropriate clearing and settlement arrangements so that claims and obligations are managed in an orderly, acceptable, predictable, and incontestable way. These post-trade and essentially back-office transaction processing arrangements, themselves complex organisational, institutional and technological assemblages, are vital to the efficient, secure, and problem free operation of financial marketplaces. They are a crucial mechanism that makes possible the coming together between marketplace participants interested in engaging with each other in repeat transactions, but that also 'script' these interactions in a way that reconciles the need for the legal determinacy that must underpin the ownership and transfer of titles to securities and other financial instruments with the need for the operational flexibility that makes possible the most efficient deployment of the scarce collateral of market participants (Sommer 2001).

By separating the price negotiation parts of a financial transaction from the resulting transaction processing aspects, the entanglement of a 'trade' in potentially messy organisational, legal, and procedural structures is "bracketed out" (Callon 1998b) and moved to another 'space'(Millo, Muniesa, Panourgias and Scott 2005). This enables the transacting parties to trade in a much more frictionless and continuous manner, that gives the impression, referred to earlier, of "disembodied systems generated entirely in a symbolic space" with traders dealing "via electronic brokerage systems disengaged from local settings" (Knorr-Cetina 2005). This also has implications in terms of both the basic efficiency, or economy, of the organisation and processing of transactions, but also in terms of the functioning of a financial marketplace as a "calculative collective device" (Callon and Muniesa 2005, Millo, Muniesa, Panourgias and Scott 2005).

The central role this often obscured and taken for granted 'plumbing' of the financial markets plays in their functioning in terms of *who* can trade *what* with whom and *how*, but also in terms of making the calculative functions of these markets possible, is not always immediately obvious, even to those involved in market transactions. In an informal conversation about clearing and settlement processes, one hedge fund trader commented: "I don't care about the plumbing, as long as water comes out of the tap" [8].

The growing interest in financial marketplace integration has lifted the clearing and settlement arrangements of financial marketplaces out of their obscurity and highlighted their importance to their functioning. From humble 'plumbing', these arrangements have now become key strategic locations in terms of defining the boundaries of a particular financial marketplace or trading venue and formatting the complex relationships that link together participants into a defined market community. As the boundaries that defined particular financial marketplaces and trading venues start getting renegotiated, the strategic position of the clearing and settlement systems at the confluence of the institutional and technological arrangements of financial marketplaces makes them an idea vantage point from which to study the interaction and mutual shaping between the human and non-human entities involved in the development of cross-border financial marketplaces, especially with regards to the role of ICTs in these processes.

Although the need for cross-border financial market infrastructures is generally accepted by industry stakeholders and seen as an important business opportunity, the route for reaching this goal and the eventual design and architecture of the resulting structures and techno-institutional regimes is controversial and contested by both commercial and public policy agencies. This is because the ICT-based common clearing and settlement infrastructure

[8] The comment brings to mind a broader discussion put forward by Thrift around the notion of a "technological unconscious", especially when he writes: "These very basic sendings and receivings of sociotechnical life – and the modest but constant hum of connection and interconnection that they make possible – have often been neglected. But it seems clear to me that as we move into an era populated by more and more objects whose raison d'e^{a}tre is precisely to hone such sendings and receivings so the task of understanding becomes far more pressing" (Thrift 2004, p.175).

that will emerge out of this struggle will embody the cultures, definitions, semantics, norms, regulations, and laws that will govern and shape the functioning of the cross-border capital markets of the future. This, in turn, will have significant consequences and implications in terms of the future positioning of both commercial and state entities in the emerging new global financial order.

The doctoral research presented in this dissertation examines these issues by focusing on an on-going securities marketplace integration initiative by Euroclear, the corporate entity formed out of the merger of the securities settlement system operators of the UK and Ireland, France, Belgium, Holland and international central securities depository (ICSD) Euroclear Bank. This initiative provided a unique setting for studying the process of socotechnical design and development involved in the integration of a number of different existing concrete securities marketplaces. The research approached pursued provides distinctive insights into how the human and material arrangements that emerge out of this process are coded into the emerging ICT platform and how, as this platform takes shape, it starts to impact the world around it. As Akrich writes in relation to the study of technological objects and artefacts, "if we want to describe the elementary mechanisms of adjustment, we have to find circumstances in which the inside and outside of objects are not well matched ... find disagreement, negotiation, and the potential for breakdown" (Akrich 1992, p.207). The attractiveness of the proposed research setting is that it has all of these characteristics.

Problem Statement

As discussed above, the starting point of this research project has been to try and better understand why actual financial marketplaces have remained so stubbornly non-global, despite the continually increasing volumes of cross-border financial activities and capabilities of ICTs in terms of enabling ever faster and ever-cheaper remote financial interactions.

This overall concern encompasses a number of more specific questions that this dissertation attempts to answer, such as:

- What are the relationships between markets, marketplaces, and ICTs and how do these shape each other?

- What can be learned about markets as abstract concepts, marketplaces as places where actual exchanges take place, and ICTs from such an understanding?

- What is involved in the integration of concrete financial marketplaces and what role do ICTs play in this process?

- What are the likely broader implications of such integration?

The dissertation aims to answer these questions by studying an initiative to fashion, using ICTs, a cross-border financial marketplace out of a number of existing jurisdictionally-specific legal, institutional, regulatory, social, cultural, and ICT elements.

To do this, the research aims to profit from the opportunity provided by the ongoing Euroclear initiative for the development of a cross-border settlement system for securities trading between the UK and Ireland, France, Belgium, and Holland to follow the organisational, institutional, and ICT reconfiguring that will flow from this and to study and better understand the interaction and reciprocal shaping that takes place in such a situation between the human and non-human entities involved and how the two shape each other in the process.

This is done through the tracing of the transition from the conceptualisations that have acted as the starting point for the initiative and participated in bringing about the necessary shared meanings among the relevant stakeholders, via dealing with the practicalities of developing a cross-border securities settlement system, to the establishment of a durable material entity that will

make possible the transfer of legal title to financial securities across marketplaces and jurisdiction. Thus, a new market architecture for securities trading comes into being, with a new allocation of roles and capabilities among the human and non-human entities that comprise a financial marketplace.

Outline

The dissertation continuous with a chapter that introduces a number of the literatures considered in relation to the research setting to be studied and the questions to be explored. Some of their central features are outlined and compared and the reasons for the final choice of approach adopted in this research, and informed by a particular body of literature, explained.

The next chapter starts by presenting, in some detail, some of the central concepts, assumptions, and research concerns of the approach adopted for this research project, primarily from actor network theory. Moving from the general to the more specific, the chapter then goes on to show how the more general concepts and concerns of actor network theory relate to the studying of financial markets and marketplaces.

The dissertation then moves on in the next chapter to describe the practicalities associated with translating the conceptual underpinnings of actor network theory into a concrete research effort relating to the specific research setting of studying the design and development of a cross-marketplace and cross-border ICT-based securities settlement system. Particular attention is given to the use of documentation in this process of design and development as documents were identified early on as playing central role in the bringing together of the human and non-human entities that would constitute the new settlement system and formed a key part of the consultation process through which the new system gradually moved from concept and words to an actual material entity. The chapter concludes with a section on the processing of the empirical material used and an explanation of how some research techniques used in the study of social networks were appropriated and adapted for use in the study of heterogeneous networks of humans and non-humans.

In the chapter that presents the research setting studied and that follows on from the chapter on the methodology used, a primarily textual narrative, based on a combination of documentary material and interviews and that describes how the new settlement system progressed from concept to thing and what controversies it encountered in the process, is presented.

This chapter forms the foundation for the discussion chapter that follows in which the account of how the new settlement system takes shape in a material way is related to some of the conceptual concerns of the research approach chosen and the litterateur it part of. The discussion focuses, in particular, on three areas of interest. The first relates to the need, where the integration of financial marketplaces is being considered, to look beyond the integration of ICTs to more intricate processes of sociotechnical rearticulation and reconfiguration. The second examines how, as the new system starts to gain a material dimension that needs to interface with the world around it, through the negotiation of the practicalities of these contacts, trials can often ensue if the links that need to be established are in some way problematic that render explicit many underlying assumptions and features of the sociotechnical networks the be linked and through the resolution of which new knowledges and understandings gain currency. The third and final area of the discussion examines how the insights gleaned from the research setting relate to debates regarding the concept of markets itself and also to distinctions between markets and marketplaces.

The concluding chapter sums up these three discussions, links them back to the initial research questions that motivated the project and also highlights what the main contributions of the research are considered to be.

Literature Review

This section presents a review of some of the bodies of academic literature that were considered during the design of the research project and which were seen as providing useful insights regarding the studying of markets and ICTs.

Relevance was judged, on the one hand, in terms of the ability of these bodies of thought to inform ways of viewing and conceptualising markets, the relations and interactions that constitute them, and the technologies that underpin them and on the other hand in terms of providing ways of studying, understanding and analysing the design and development of ICTs that enable the conclusion of transactions among participants in financial markets.

The chapter is divided into three sections that present respectively the literatures examined in relation to ways of looking at and studying science and technology, markets and marketplaces, and ICTs. What unifies the three sections and the bodies of literature examined within them is a concern with the mutual shaping of the social and material that they share.

Science and technology

Sociology of scientific knowledge

In a research project concerned with the mutual shaping of society and technology, it is useful to follow the lineage of some of the main bodies of thought that address such concerns. One important forerunner of a number of approaches has been the sociology of scientific knowledge that has focused on the analysis of the actual content of scientific ideas, theories, and experiments (Pinch and Bijker 1987, Williams and Edge 1996). It emerged as a distinct field out of the sociology of science literature which was primarily concerned with science as an institution, focusing on the norms, practices, career patterns, and reward structures of those involved in science (Pinch and Bijker 1987).

One distinct feature of the sociology of scientific knowledge literature has been that scientific knowledge is seen as a social construction and not a mirror held up to nature, with phenomena always susceptible to more than one interpretation (Pinch and Bijker 1987). Scientific knowledge – as well as technological practices – are seen as built through a process of construction and negotiation as conflicting social groups reach, or impose, specific outcomes and so conclude or close a particular dispute or controversy (Pinch and Bijker 1987).

A key tenet of this approach to the study of science is that all knowledge and knowledge-claims are to be treated as socially constructed, regardless of their claim to truth. Within such an agenda, the mechanisms involved in the genesis, acceptance and rejection of knowledge-claims in the social world are of central interest for study. With scientific knowledge seen as one out of many knowledge cultures, the success or failure of particular knowledge cultures is treated as a sociological rather than epistemological issue.

This broad area of investigation was one of the precursors of what has now become more widely referred to as science and technology studies. According to Pinch and Bijker (Pinch and Bijker 1987), a key step towards a joint research agenda that encompasses both science and technology was the Empirical Programme of Relativism (EPOR), located within the broader field of the sociology of scientific knowledge. This programme focused on empirical studies of contemporary scientific developments and, in particular, scientific controversies.

The *interpretative flexibility* of scientific findings and concepts before consensus emerges is underlined and, as a result, the mechanisms that help bring about 'closure' are seen as a key focus of study, as is the way that such closure mechanisms then relate back to the broader social whole. Controversies, as a result, represented one of the central methodological foci of research as most of the actors involved are defined – and define themselves – around them with the resulting interactions leading to the production of new knowledge (Pinch and Bijker 1987).

In this research, controversies are important on several levels. Firstly, they help to focus the research approach by providing a way of overcoming the complexity and limiting the extent of the research setting, focusing attention on the debate around the controversy in question rather than the actors themselves and their nature. In this way, the actors involved describe and articulate the controversy, its parameters, and the terminology used in their own terms. Second, controversies also provide a guide in both the collection and analysis of the empirical material by providing a focus for effort and attention and a trace that can be followed through time. Finally, since aspects of the controversies in the study are on going, controversies also provide a familiar way to organize the implications of the findings for practice.

Social construction of technology (SCOT)

Out of the aspiration to better understand and explain the relationship between science and technology and to develop a sociology of technology that, like the sociology of scientific knowledge, would treat technical knowledge in a symmetric way, with the success of an artefact needing to be explained rather than be seen as explaining the success of a certain body of knowledge behind it, came the Social Construction of Technology (SCOT).

In this school of thought, the development process of technological artefacts is often seen as a multidirectional, not a linear, view of development. Linearity is only imposed retrospectively. SCOT studies thus share the concept of *interpretative flexibility* with EPOR and the sociology of scientific knowledge, but this time also applied to artefacts. Not only to how they are interpreted in their use, but also that the same flexibility exists in the way they are designed (Pinch and Bijker 1987).

A key concept in SCOT studies is that of *relevant social groups,* all members of which share a set of meanings in relation to a specific artefact.

> "In deciding which problems are relevant, the social groups concerned with the artefact and the meanings that those groups give to the artefact

> play a crucial role: a problem is defined as such only when there is a social group for which it constitutes a 'problem'."[9]

Identifying, understanding, and describing the relationship between such entities and artefacts are central methodological and empirical concerns of SCOT studies and research.

> "The key requirement is that all members of a certain social group share the same set of meanings, attached to a specific artefact."[10]

Relevant social groups are seen as crucial in the definitions of functions and resolution of controversies out of which change and development take place and stabilisation is reached with settlements in which the interests of a large enough group of relevant users are reconciled.

Problematic issues arise when one questions whether an artefact actually ever becomes fully stabilised, how the boundaries of relevant social groups are defined, whether any two individuals can have an identical relationship with a particular artefact that defines their belonging to that group, whether this relationship with an artefact is ever stable rather than dynamic and emergent, and in the final analysis, whether the artefact shapes the individual or vice versa and why in certain situations different relationships between social groups and the same artefacts prevail. It is partly as a response to these questions that the concept of technological frames is introduced and is crucially important to SCOT-inspired studies.

One of the key strengths of the SCOT approach is that because it is concerned with understanding the mechanisms through which a technological artefact is developed through its interaction with social actors and how it is eventually stabilised, it provides a valuable approach to studying and understanding processes of technological development and the relationship of this development to practices such as design. The clear framing provided by the use of relevant social groups defined by their relationship to the object or artefact

[9] In (Pinch and Bijker 1987, p.30)
[10] In (Pinch and Bijker 1987, p.30)

and the introduction of the concept of technological frame help to simplify and make more manageable the study of often highly complex and messy phenomena and research settings, while preserving the emergent nature of these settings and avoiding the use of taken-for-granted conceptualisations and theoretical constructs that are built on reification and objectifications

Social history of technological systems

This body of literature approaches technology from the perspective of historical accounts of the design and development of large-scale network technologies and systems such as electricity generation and distribution systems (Hughes 1983, 1987). It shares some common ground with both SCOT and actor network approaches.

Hughes describes such technologies as systems made up of many "messy, complex, problem-solving components", both "socially constructed and society shaping" (Hughes 1987, p.51). Hughes sees all these components, "whether physical or non-physical" as interdependent artefacts all of which contribute directly or indirectly to the common goal of the whole. This approach stresses the importance of paying attention in any study of large technological systems to the different but interlocking elements that compose them and that can range from physical artefacts to institutions and must include the environment of the system, not understood as the social context of the technological system, but as external "intractable factors not under the control of the system managers" (Hughes 1987, p.52). It is important, therefore, to study the integration of technical, social, economic, and political aspects of systems (Hughes 1987)

> "Technological systems also include organisations, such as manufacturing firms, utility companies, and investment banks, and they incorporate components usually labelled scientific, such as books, articles, and university teaching and research programs. Legislative artefacts, such as regulatory laws, can also be part of technological systems"[11]

Hughes suggests that the goals of such systems have to do with "reordering the physical world in ways considered useful or desirable, at least by those

[11] In (Hughes 1987, p.51)

designing or employing the technological system" (Hughes 1987, p.53). This usually has to do with making the system more productive. Hughes also stresses the importance of interfaces and subsystems. He sees such systems and infrastructures as essentially evolving, but suggests that this evolution follows "a loosely defined pattern" while acknowledging that without a large enough sample it is not possible to make hard statements about this.

Key concepts deployed by Hughes include those of *reverse salient*, *critical problems*, *technological styles*, and *technology transfer*. He also draws attention to historical evidence of how, as the complexity of the infrastructure grows and the number of components in the network increase, problems of control appear that often lead to intense crises of control. These can be linked to the development of "reverse salients" where component elements of the system fall behind or out of phase with the others that make up the whole.

Hughes argues that, as systems grow and evolve "they acquire style and momentum" (Hughes 1987, p.56) and that the former is proof of the social construction of technology as it provides historical evidence of how it is possible to achieve equally valid outcomes through often radically different designs. Therefore, "as there is no one best way to paint the Virgin", there is no "one best way to build a dynamo" (Hughes 1987, p.68). Hughes also suggests a dichotomy between conservative and radical innovation and design strategies with the appearance of reverse salients resulting in crises that demand a radical innovation that may then eventually lead to the formation of an entirely new system.

The importance of analysing multiple, interlocking, artefacts in the study of large systems and the possibility that technological systems are shaped by the social as well as the material ties that constitute them are important premises for the research undertaken in this thesis.

One of the central differences between systems-based social history of technology approaches such as that of Hughes and actor network approaches is that the systems approach taken by Hughes always presupposes a boundary

that delineates the system from the wider environment within which the systems exists. There is therefore a clear inside and outside to such technologies and a need for a distinction between micro and macro studies.

In order to develop an approach that supports an analysis that extends from the smallest detail of technological design to encompass social, economic, and political aspects, we must turn to the related literature of actor network theory and Science and Technology Studies (STS).

Actor network theory and science and technology studies (STS)

While at first appearing to share a number of features with SCOT approaches to the study of science and technology (e.g. focus on understanding the relationships and links between people and things and how the two are mutually shaped), actor network theory is also very different.

First of all, the actor network approach is based on a very different understanding of the relationship between human and non-human entities. While SCOT takes a clearly constructivist approach in which there is no doubt that nature and reality are constructed by humans through *their* interactions in a social collective, actor network approaches acknowledge that there is a reality that is independent of society and human activity, that cannot be modified easily, but that it is not possible to say much about that without the participation of humans and their constructs. Objects and subjects do not have an independent existence, but are defined through their interactions. Nature becomes meaningful through its interaction with humans and their worlds.

At the point where this interaction between humans and the material world takes place, a version of reality as articulated in networks of relationships between humans and other human and humans and non-human elements. Each network has its own topology and morphology that gives meaning and identity to the elements that comprise it. As a result one can talk about versions of reality and of objects that are particular to that configuration. Within such a circumscribed system of meaning and understanding, truth is linked to

statements that can be true or false within that system but no such system can claim to have some privileged access to an external and independent reference point. The strength of particular claims relates to the persistence and extent of the networks of human and non-human relations that they fit with unproblematically. The statement "Everest is a taller mountain than Kilimanjaro" has meaning as a hybrid of the natural properties of the two mountains in question, but in conjunction with human concepts and institutions such as measurement, height, the concept of a mountain and so on. Before such human interventions are made, it is impossible to say or even understand anything about the two mountains. As truth must relate to statements (Latour 1987, 1999), even the most uncontested scientific theories do not *reflect* reality, but represent a particular version – or explanation – of reality that works, or hangs together, within a larger or smaller network of people, ideas, and things. The bigger and more durable the network, the more uncontested the version of realty it outlines. In the same way, objects do not have an independent existence and attributes and properties, but are always defined through their interactions with humans and human constructs. As Law points out: "an object is an effect of an array of relations" (Law 2000, p.1).

In general, actor network approaches reject the notion that objects are 'dumb' things that are only endowed with properties and attributes by 'knowing subjects' and the idea that subjects are autonomous agents that gain their subjectivity through interactions among themselves and the production of knowledge and consciousness. Instead, they are formed – as is their understanding of the world around them – through their interactions with objects that shape them just as much as they shape the objects. Therefore both subject and object are mutually defined through the particular topology of their relations with one another and with other human and non-human entities around them. There is no such thing as a pure object or a pure subject, but dynamic networks of human and non-human entities with different meanings, identities and roles according to the particular circumstances within which their interrelations exist and take place (Latour 1999).

A key focus of study therefore becomes to describe, decode and explain these complex interrelations between people, things, ideas, concepts, even animals and to understand how they are put together, how they are *articulated*; to understand the particular syntaxes of these linkages and the logic in them that enables the whole network to hold together rather than fall apart (Akrich and Latour 1992, Latour 1992, Law 1992, Latour 1996b, Law 2000). Only then can the success or failure of these heterogeneous assemblies be understood in their own terms and the reasons for their persistence, stabilisation, development, or change be properly grasped and understood without falling into the pitfalls of either social constructivism or relativism on the one side and technological determinism or naïve realism and objectivism on the other (Latour 1987, 1996b, 1999).

In relation to more technologically-specific research settings, the most valuable contribution of actor network approaches is the way they enable – even facilitate – the researcher to deal with the heterogeneity of technologies and technological artefacts, both simple and complex, by treating human and non-human elements symmetrically as parts of tightly intertwined assemblies of human and non-human elements, without privileging or taking for granted either of the two in accounts and analyses of phenomena.

In order to be true to this symmetry, it is important that the researcher does not bring an external theoretical framework to the research setting, but, as part of the research itself, seek to describe and understand the conceptual frameworks and tools used and deployed within the heterogeneous network being studied and decoded. As Law writes, "it is important not to start out assuming whatever we wish to explain" (Law 1992, p.380). A theory is an internal part of the network being studied and not an external device to be imposed by the researcher on the research setting. Theory is not above or below the setting being studied, but an integral part of it. It is only through the meticulous tracing of the relationships that compose it and the developing of an understanding of the way these articulations hold together that underlying concepts and theories can be brought to light. Only by focusing on the relationships and interactions between human and non-human entities and their syntax and articulation and

how these might succeed or not in stabilising and reproducing themselves, rather than their properties, is it possible to avoid limiting and potentially distorting reductionist assumptions built into traditional notions of subjects and objects.

As Law points out, this is a way of "suggesting that society, organisations, agents, and machines are all effects generated in patterned networks of diverse (not simply human) materials" (Law 1992, p.380). The network is an attempt to organise and order these elements that may be social, technical, conceptual, institutional, or textual, but the success of the ordering can be limited by their properties or preferences. As Law explains, they are fitted together (Law 1992). Once this has been successfully achieved the network can be represented as an entity in its own right that forms the node of a new – higher level – network. This can then be described by an action and the author of that action (Law 1992). Networks, therefore can order interactions, but might equally break down or experience reconfiguration. For actor network studies, to describe, understand, and explain the ordering of relations between human and non-human entities has to be at the centre of any enquiry into how devices, agents, institutions, or organisations are generated (Law 1992).

It is in situations of breakdown or reconfiguration that often submerged and stabilised networks underneath a node can re-emerge and become observable. Analytically such moments are the most fruitful to investigate. Establishing the degree to which the social shapes the technological or vice versa becomes an empirical question rather than an a priori assumption (Law 1992). It becomes possible "to explore and describe local processes of patterning, social orchestration, ordering and resistance" – or 'translation' in actor network terminology – through which "ordering effects such as devices, agents, institutions, or organisations" are generated (Law 1992, p.386).

Drawing from this analysis, the issue of design can be seen from an actor network perspective as a strategy of ordering or translation, notions seen as particularly useful in relation to the research being undertaken as they do not necessarily presuppose the existence of a designer or initiator of the design

process although there is some conceptual leeway for the existence of "centres of translation".

Markets and marketplaces

Although what constitutes a market is difficult to define and the subject of contestation (Rosenbaum 2000), markets have long been considered as one of the archetypal mechanisms for the ordering of human interactions (Thompson, Frances, Levacic and Jeremy 1991).

The study of markets and market mechanisms has become increasingly the focus of disciplines other than classical economics (White 1981, Granovetter 1985, Carruthers and Babb 2000) and this section attempts to outline the central features and concerns of some of these approaches with relevance to this research.

Economic sociology and the embeddedness of markets

Markets – especially financial markets – depend on a complex network of social, legal, fiscal, economic, administrative, and technological links and arrangements for their functioning. Taking this as a starting point, a growing body of literature from the field of economic sociology and adjacent areas of social study has sought to study markets, marketplaces, and market phenomena from the point of few of their relations to the wider social structures within which markets and the participants in exchange transactions that help bring them about exist (Granovetter 1985, Granovetter and Swedberg 1992, Fligstein and Mara-Drita 1996, Fligstein 1997, Carruthers and Babb 2000, Fligstein 2001, Rauch and Casella 2001).

Economic sociology challenges the view of economic agents as atomised and inherently rational and self interested beings and markets as assumed abstract and formal economic entities that operate in a void, detached from social, institutional and technological components that "structure ownership, control, and exchange relationships in the economy" and separate from the world around them, which is reduced to an externality (Rauch and Casella 2001).

With markets seen as a "joint social construction" by those who participate in them (White 2002), the study of such processes of joint construction is an important focus of research in economic sociology (Granovetter 1985). A growing body of empirical studies of markets as actual spaces that are embedded in often messy social and other relations and structures and in which economic exchanges grounded in "ordinary experience" occur (Callon 1998b), have accompanied the development of this area of studies.

By focusing attention and research interest on the study of the interrelations between markets as abstract concepts and the practical, complex, and physical reality of actual markets and economic activities, the economic sociology literature has opened-up a wide research area for studies of markets and economic exchanges from disciplines other than economics. Even within such studies of markets and marketplaces, however, the roles of technology and the material arrangements that underpin economic interactions, and in particular ICTs, have not been a central focus.

MacKenzie, in *"An engine, not a camera: how financial models shape markets"*, writes about this:

> "Economic sociology ... has been strong in its emphases on matters such as the embedding of markets in cultures, in politics, and in networks of personal interconnections. It has traditionally been less concerned with the systematic forms of knowledge deployed in markets or with their technological infrastructures ..."[12]

With the conclusion of market transactions, especially in the case of financial markets, increasingly predicated on the existence of ever-more complex and sophisticated electronic data communication and processing systems that are part of a complex network of intertwined institutional, organisational and technological components, this lack of attention to the role of technology and ICTs has become an increasingly conspicuous gap in such approaches to the study of markets and economic activities.

[12] In (MacKenzie 2006, p.25)

As a response to such critiques, more research attention has started to be directed towards better understanding the mutual shaping between human and material elements that takes place in order to make markets and marketplaces work, and in particular the back-office trade processing aspects of market transactions that are often highly dependent on ICTs. Within this context, the clearing and settlement (or transaction processing) activities of financial markets and marketplaces have started to be seen, not simply as simple processing mechanisms linking two transacting parties, but as an integral part of the broader sociotechnical processes that structure and organise economic exchanges in financial markets, contribute to their calculative functions, and give them their particular characteristics (Millo, Muniesa, Panourgias and Scott 2005). The legal, institutional, fiscal, economic, administrative, governance, risk management and technological structures with which actual financial markets and marketplaces are entangled – and of which the clearing and settlement systems are an important part – are increasingly viewed as integral components of markets and marketplaces that have implications on their functioning and outcomes (Callon and Muniesa 2005, Millo, Muniesa, Panourgias and Scott 2005)[13].

Historical accounts of the emergence of financial markets

The importance of clearing and settlement systems in the development and success of financial markets can be seen in historical accounts of the development of financial markets from antiquity to today (Lane, Mueller and American Council of Learned Societies. 1985, Williams 1986, Moser 1998, 1999, Padgett 2001).

Initially a shared physical venue/space in which the administrative and processing elements of transactions between market participants would be expedited, clearing and settlement entities soon also became informational and

[13] This growing interest in the devices and mechanisms that underpin the workings of financial markets and marketplaces, in particular the back-office trade processing aspects of market transactions such as clearing and settlement arrangements, is also mirrored in other disciplines and among practitioners and those engaged in the conduct of public policy (Bernanke 1990, Moser 1998, 1999, Fleming and Garbade 2002, Pirrong 2002).

organisational spaces, acting as the repositories of common rules, processes, methodologies, meanings and vocabularies shared by all market participants and defining the extent and nature of the obligations of participants to one another (Williams 1986, Moser 1998, 1999, Millo, Muniesa, Panourgias and Scott 2005). In this way they served to bring market participants closer in terms of shared and mutually recognised and accepted organisational and technological arrangements. By providing crucial common material links and procedures connecting a group of transacting parties engaged in recurring dealings, these arrangements outline a clear boundary and define precise entry and exit points to a marketplace within which mutual obligations among the participants circulate in an unambiguous and unalterable way. By enabling the diverse back office administrative procedures of market participants to interact in a standardised way through these processing arrangements, transactions could be made more efficient, less complex and, as a result, many unnecessary risks associated with trading could be reduced, or at least mutualised (Millo, Muniesa, Panourgias and Scott 2005). As such, clearing and settlement entities have had a central role in structuring the linkages and relations between market participants through time and space, becoming the spaces in which organisational and physical ties, coordination mechanisms, and relations of reciprocity between market participants were forged.

By being physically located in a place that was mutually convenient for the transacting parties in terms of reducing both the number and distance of journeys needed for the exchange of the documentation necessary for the conclusion of a transaction, clearing and settlement entities increased the efficiency and security of trading by providing a shared meeting point or place of congregation where the exchange and processing of the necessary documentation (contracts, payments, exchange of cheques) could take place in a problem-free way (Millo, Muniesa, Panourgias and Scott 2005). No matter what the particular internal processes and definitions used by each individual counterparty to a trade might be, once a financial exchange entered the clearing and settlement space, a common vocabulary and set of meanings would be adopted and applied. Seen in this light, clearing and settlement entities

represented a form of shared organisational and informational interface or protocol.

Even in the pre-electronic age the status and nature of this interconnectivity and the interfacing function of clearing and settlement systems and platforms has been central to the operation and shaping of financial markets. This represent a key element of the value that clearing and settlement structures impart to the financial system as a whole as well as to individual participants. By linking the back office operations of participants in financial markets, clearing and settlement systems thus make possible the conclusion of the transactions among participants in a structured way and are essential for the operation of financial markets and the price discovery process. They do this by helping to establish, structure, and maintain links between transacting parties in a way that makes it possible for any particular pair out of a large number of possible counterparty combinations to come together for the purpose and duration of a transaction while also ensuring a secure, seamless, incontestable, and eventually final interaction between the two sides of the transaction over a common techno-institutional platform. As a result, repeated interactions between internally differently structured organisations with different internal procedures and systems can take place, with the clearing and settlement system providing a platform that enables non-permanent but enduring relations and connecting structures among the participants to exist. This makes it possible for a "group of agents who pursue repeated, enduring exchange relations with one another" (Rauch and Casella 2001), to do so without the need for an external hierarchical authority to coordinate and structure these activities, but, instead through the coordination and structuring provided by a shared organisational and technological mechanism.

Developing an understanding of the way that the mutual shaping of technology and social, institutional, and economic factors structures ownership, control, and exchange relationships in financial markets through clearing and settlement arrangements is one of the central concerns of this research project.

Science and Technology Studies and the study of markets and marketplaces

While science and technology studies (STS) have been primarily associated with the natural sciences, technology, and technological objects and artefacts, economics, financial practices, and market mechanisms can also be seen as part of the broader field of technoscience[14].

While the focus of actor network studies may have initially been the natural sciences and technology, Callon, in "The Laws of the Markets", has focused explicitly on using an actor network approach to study settings traditionally seen as being in the domain of so-called social sciences such as economics (Callon 1998b).

One of the central criticisms of previous approaches to the study of markets and marketplaces that emerges from this extension of science and technology studies to the field of economic activities is the lack of attention given to the physicality and materiality of markets and marketplaces and the artificial separation assumed as existing between the actual economy and economic theory that this implies (Callon 1998b).

Callon initially backs economic sociology's criticism of traditional economic theory that because such an approach ignores the embeddedness of markets and economic activity in complex social structures, economics as a discipline may be in danger of over abstraction and a lack of realism and losing touch with central objects of economic activity such as 'real' markets. Illustrating this point Callon, in his introduction to "The Laws of the Markets", presents the following quote from North:

> "It is a peculiar fact that the literature on economics ... contains so little of the central institution that underlies neoclassical economics – the market."[15]

[14] The reason the term technosciences is used in STS to describe its field of interest is because it is a term that overcomes what are seen as the arbitrary disciplinary divisions found in traditional approaches to the study of the natural sciences, technology and technological knowledge, and society.
[15] In (North 1977)

Callon goes on to suggest that the separation between the market as a concept or as "the abstract mechanisms whereby supply and demand confront each other and adjust themselves in search of a compromise" and the marketplace as a "thing", or as a place "far closer to ordinary experience" and in which "exchange occurs", needs to be overcome for a better understanding of economic life to be possible (Callon 1998b, p.1). He is also, however, at variance with economic sociology approaches that make the assumption that "there exists a thing – the economy – which a science – economics – has taken as its object of analysis" (Callon 1998b, p.2). Callon dismisses the assumption, whether in economic sociology or traditional economics, that economic theory simply tries to describe an economic reality 'out there' that is independent from theory. Instead, he suggests, economic theory is as much part of everyday practical economic activity and as such also shapes, or helps to *perform* economic reality:

> "... economics, in the broad sense of the term, performs shapes and formats the economy, rather than observe how it functions."[16]

This point draws from one of the central tenets of actor network approaches to the study of science and technology, that all actors – or elements – of an actor network, whether human or non-human, participate in a *performance* of reality as that is defined within that particular set of associations, relations, and links between the heterogeneous elements that comprise that network. For Callon, both the economy and economics have to be seen – just as was the case in past actor network analyses of science and the natural world – as part of a wider assembly, or network, of human and non-human elements comprising of concepts, theories, devices, artefacts, people, institutions and so on. From such a perspective, neither economic activity nor scientific enquiry can be artificially divided into a separate reality 'out there' and a theory that describes that reality. The two, "economics as a discipline and the economy as a thing", just like any opposition between theoretical and practical activities, are intertwined and mutually define each other (Callon 1998b, p.1).

[16] In (Callon 1998b, p.2)

Callon, as a result, also rejects both traditional economic theory and economic sociology approaches that assume that there can be a 'pure' economic reality that is separate from the social and the messiness and materiality of everyday economic activity. For Callon, all such approaches suffer from an artificial separation they assume exists between the economic and other activities. Instead, Callon suggests, this artificial separation between economic and non-economic decision-making can be overcome by resorting to a broader concept of calculation that is both distributed between human and non-human entities, with the "material reality of calculation, involving figures, writing, mediums, and inscriptions," are seen as "decisive"(Callon 1998b, pp.4-5), and that encompasses both qualitative and quantitative aspects:

> "For an agent to be able to calculate – ie to rank – her decisions, she must at least be able to draw up a list of actions that she can undertake, and describe the effects of these actins on the world in which she is situated. This presupposes the existence in organised form of all the relevant information on the different states of the world and on the consequences of all conceivable courses of action and the access of all this information to the agent. Thus, she will not only be able to get an idea of possible goals and rank them, but also mobilize the resources required to attain them."[17]

In order to understand economic activity better and go beyond the arbitrary boundaries used to separate economic and other activities it is important to reconnect or retrace the often taken for granted complex chains of interrelations that connect objects and subjects that have become subsumed in crude mechanism of correspondence and reference. To do this, the subtle relationships between economics and the economy must be studied and analysed in general, but in particular, "relations between the market and the marketplace" (Callon 1998b, pp.4-5).

The "regularities, related to the stabilization of particular forms of organization of market relations" that although "limited in time and space ... perform behaviours" and have the "obduracy of the real", but which are also "performed by these behaviours and therefore have the contingency of an

[17] In (Callon 1998b, p.4)

artefact" (Callon 1998b, pp.46-47) need to be studied through what Callon refers to as "an anthropology of markets"(Callon 1998b, p.50). Such an approach is based on describing, reconstructing, and explaining through empirical studies the "diversity of formatting" of the relations of calculative agencies found in markets (Callon 1998b, p.48).

Social Studies of Finance

The extension of science and technology studies to economic knowledge and activities has been accompanied by the development of a progressively more well-defined research agenda referred to as the Social Studies of Finance (SSF) which is concerned with the study of the technicalities and materiality of financial markets (Preda 2002, Callon and Muniesa 2005, MacKenzie 2005, Millo, Muniesa, Panourgias and Scott 2005, Beunza, Hardie and MacKenzie 2006, MacKenzie 2006).

Research attention is directed particularly towards "the role played in those markets by technologies and by systematic forms of knowledge; the concrete, material practices of trading, risk management and regulation, and so on" (Beunza, Hardie and MacKenzie 2006, pp.721-722).

The growing body of empirical studies that is emerging out of this research agenda is shedding a new light on the conceptualisation and understanding of financial markets and marketplaces and the implication in their functioning of the techniques and mechanisms that are a part of them.

A point of central importance that emerges from these studies is that "financial and other markets ... are to a significant extent entities subject to deliberate design, and the details of their design are consequential" on the functioning and outcomes of these markets (MacKenzie 2006, p.274).

The implication of this is important, especially in relation to links between technology and markets, as MacKenzie writes:

> "... the analogy between markets and technologies may be a productive one for theorizing markets. It also suggests something more. Markets,

> like technologies, are surely means – to be tinkered with, modified, redesigned, improved, and on occasion delimited – not ends that can only be embraced or be rejected. They are not forces of nature, but human creations."[18]

While sharing a number of the concerns of economic sociology (MacKenzie 2006) and many of its criticisms of classical economic theory and "close relations to economic sociology and economic anthropology" are acknowledged (Beunza, Hardie and MacKenzie 2006), the STS heritage of SSF and recourse to the conceptual toolbox developed by STS for dealing with sociotechncial assembling has enabled SSF to transcend some of the polarisations that have become entrenched regarding questions of structure and agency in economic activities and markets. By seeing agency as distributed among human and non-human entities that always act in concert, the sterility of such polarisations is overcome. It is no longer of such importance whether humans are by their nature atomised interest-seeking, profit maximising individuals or not or whether they can be conditioned to act in particular ways by institutions, morals, or beliefs or other social structures.

The assembling of heterogeneous entities into larger and more complex, but always durable, networks does at first sight appear as if it is privileging structure over agency. Even in the most durable and unbreakable of such sociotechnical networks, however, there is circulation of objects which, while maintaining their immutability when circulating among the entities that constitute these networks, are also modified and operated on by the entities they come into contact with in some way (Latour 1996b). A good example of this is the conceptualisation of markets as algorithmic configurations proposed by Callon and Muniesa (Callon and Muniesa 2005). Drawing parallels between computers and markets as "organised social spaces", the conceptualisation of markets in such a way enables their treatment as a logical program, which implies "the existence of several solutions that can be attained by following a concrete set of instructions contingent on a specific situation and/or task ... deduced from a simple principle of action" (Callon and Muniesa 2005, p.1243).

[18] In (MacKenzie 2006, p.275)

Information and Communication Technology

Information systems as infrastructures

The radical and rapid change in electronic information processing and communication systems and capabilities of the last few decades has produced a growing interest in developing a better understanding of taken-for-granted notions such as that of infrastructures that are of growing interest because of their relevance to shared economic activity and interactions between diverse and previously discrete communities with often different processes and computing equipment.

In this context, infrastructures are seen as a useful conceptual development because of the attention they give to the increasingly shared and inter-organisational nature of ICTs and their relevance to integration initiatives across geographical, jurisdictional, and organisational boundaries.

Key theoretical insights on infrastructures come from Susan Leigh Star and Karen Ruhleder who used a study of the building of a "geographically dispersed, sophisticated digital communication and publishing system for a community of scientists" in order to develop "an analytical framework and vocabulary" to explain the relationship between a large scale infrastructure and organisational change (Star and Ruhleder 1996, p.112).

Drawing from the literature of the social studies of technology and actor networks, Star and Ruhleder take an approach to technology in general – and ICTs in particular – that sees these as heterogeneous assembles of human and non-human elements that it is not possible to separate by a clear boundary and that are defined through the interrelations between all these elements that make them.

They reject common metaphors of infrastructures based on their properties that present them as "a substrate: something upon which something else 'runs' or 'operates', such as a system or railroad tracks" (Star and Ruhleder 1996, p.112). Instead, Star and Ruhleder suggest that an infrastructure should be

defined as a "relational concept" based on organised practices that "emerges for people in practice, connected to activities and structures" (Star and Ruhleder 1996, p.112).

In such an effort, it is key to understand relationships between practices and technology and what is behind the image of infrastructures as "sinking into the background" (Star and Ruhleder 1996, p.112). Star proposes that in order to do this successfully it is vital to understand "when – not what – is an infrastructure" (Star and Ruhleder 1996, p.113).

According to Star, key questions that need to be answered in order to develop the necessary analytical framework and vocabulary include:

- How do the specific and universal get reconciled?
- How does design and development take place when there is a lack of an absolute centre from which control and standards can flow and participants are members of multiple communities and practices?

Star and Ruhleder, citing Bowker (Bowker 1994), go on to suggest that the development of large-scale technological infrastructures results in a "gestalt shift in the development of large scale technological infrastructures" in which neither things nor people are simple causal factors, but rather "changes in infrastructural relations become central" (Star and Ruhleder 1996, p.113). These, in turn, change the way practices are actually carried out. In order to better understand this, "the politics, voice, and authorship embedded in the systems" must be revealed and studied "not as engines of change, but as articulated components of the system under examination" (Star and Ruhleder 1996, p.113).

From Star's work, the key factors that a study of infrastructures needs to address are:

- Embeddedness: The degree to which the infrastructure is sunk into other social and technological arrangements
- Transparency: The degree to which an infrastructure invisibly supports tasks without having to be reinvented and renegotiated.
- Reach or Scope: The way infrastructures stretch beyond single events and sites of practice
- Membership: The way the taken-for-grantedness of an artefact or organisational arrangement is part of membership of a particular practice.
- Links with the conventions of practice: How infrastructures shape and are shaped by the conventions of a practice.
- Embodiment of standards: The taking-on of transparency by 'plugging into' other infrastructures and tools in a standardised form.
- Dependence on an installed base: Wrestling with the inertia of installed base and inheriting of strengths and weaknesses.
- Visibility on breakdown: Value importance and quality of infrastructure are revealed upon breakdown.

Common features that Star and Ruhleder suggest infrastructures share are:

- Lack of absolute and clear boundaries
- Ambiguity and multiple meanings of usage
- Network effects
- Politics of reinforcement as more important participants become part of the network

For Star and Ruhleder an infrastructure "occurs when the tension between the local and the universal is resolved" and "local practices are afforded by a large-scale technology that can then be used in a ready-to-hand fashion" (Star and Ruhleder 1996, p.114).

To understand how such a process might take place, Star says it is important to understand how "communicative processes are entangled in the development

of infrastructure" and how the "delicate balance between language and practice across communities and parts of organisations" is achieved (Star and Ruhleder 1996, p.117).

One key characteristic of infrastructures found across the relevant literature is that infrastructures are a public (shared) resource that link together many distinct and separate organisational entities. Shared, in this sense, means that control and/or ownership of the infrastructure is outside the direct remit of the users/participants.

Focusing the notion of infrastructures to the study and design of information systems, Hanseth develops the concept of information infrastructures with the aim of substituting "IT [Information Technology] with ICT [Information and Communication Technology]" in order to develop a new theoretical approach that deals with "the so-called convergence between information and communication technologies" (Hanseth 2002). As with Star and Ruhleder, communication for Hanseth becomes as important as information in the context of information infrastructures (Hanseth 2003). Hanseth argues that changes in the nature of IT and its uses have made it necessary to develop new theoretical and conceptual tools and methodologies that reach beyond those already found in the field of information systems studies and can inform new approaches towards the design of such systems.

In addition to the shared aspects of information infrastructures, Hanseth argues that they also change, or evolve, over a longer time compared to traditionally understood information systems. For Hanseth, these two features are intimately linked, because, he argues, the shared nature of an infrastructures means that their value increases with the number of users sharing it, thus creating an installed base effect that in turn produces inertia (Hanseth 2002).

Central features identified as important by Hanseth in relation to the concept of information infrastructures include lock-ins, gateway technologies, enmeshed networks of agents and alliances, and the amplification and rapid transmission of unpredictable side effects (boomerang effects).

Interfacing and interoperability standards are also of central interest to Hanseth in the context of an information infrastructure as they make it possible for many disparate users from different organisational entities to share the same infrastructure. Key characteristics of information infrastructures as they emerge from Hanseth's writing include openness, indefiniteness, use of generic technologies, non-definite user base, and the dissolution of boundaries.

All this adds up to a dramatic increase in complexity, which, Hanseth argues, makes it impossible to apply traditional project management methods to information infrastructures and also results in significant differences in their design and development compared to traditional information systems.

Summary

As can be seen from the review presented in this chapter, the one body of literature that has spanned all three of the areas considered in a reasonably consistent way is that based on actor-network approaches grouped under the broader title of science and technology studies (STS). Although it can be argued that this is also true for some of the other approaches considered – for example there is a significant body of literature concerned with the study of ICTs and information systems from the social construction of technology perspective and many of the approaches to markets in economic sociology are also informed by a similar interest in understanding the processes of social construction involved in their establishment (Fligstein 2001, White 2002) – these do not link together in a coherent research programme with a clearly identifiable internal logic as is, for example, the case with STS and its extension to economics and finance.

The ability of actor-network approaches to cross traditional disciplinary boundaries is linked to their central ontological premise of only assuming associations of human and non-human entities as fundamentals in any research setting (Latour 1987, pp.140-141). That means that many categories and divisions accepted previously in a taken-for-granted way, such as for example

that between social and economic activities criticised by Callon in both traditional economics and economic sociology (Callon 1998a) or those between nature and society or science and technology criticised by Latour (Latour 1987, 1999), are rejected as artificial and subsumed into the broader realm of technoscience.

While STS has a very clear notion of technology in its broadest sense, there is has been much less specific engagement with ICTs. The growing use of actor-network approaches in the study of ICTs (Adams and Berg 2004, Allen 2004, Faraj, Kwon and Watts 2004, Mahring, Holmstrom, Keil and Montealegre 2004, Marres 2004, Moser and Law 2006) and the influence of some key actor-network tenets in re-conceptualisations of information systems outlined in the earlier section on infrastructures (Star and Ruhleder 1996, Hanseth 2002) indicate that effort is being directed towards filling this gap.

At the same time, despite the significance of markets as key mechanisms for the coordination of social interactions (Thompson, Frances, Levacic and Jeremy 1991) and the importance of ICTs in the re-framing of market-based interactions brought about by e-commerce, there has been limited attention given in the information systems (IS) literature to the relationship between ICTs and markets and the generation of new insights for the conceptualisation of markets resulting from the increasing involvement of ICTs in their functioning. With concerns about how to differentiate IS from "computer science on the one hand, and organisation studies on the other" (Hanseth, Aanestad and Berg 2004, p.116) and calls in the information systems field for a focus on the interaction between ICT systems and social systems (Lee 2001, pp.iii, Hanseth, Aanestad and Berg 2004, p.116), it is unavoidable that markets, one of the elemental forms of social organisation, must be a central point of attention in any such a vision of the information systems field. This is especially the case regarding financial markets and marketplaces where the interaction between ICT and social systems is especially intense and dynamic.

This research project hopes to contribute to filling both these perceived gaps and the following two chapters will show how it has attempted to adapt key

concepts and approaches from STS for use in the design an implementation of a research plan for studying an initiative to integrate the securities markets of the UK and Ireland, France, Belgium, and the Netherlands through the development of a common ICT-based settlement system.

Conceptual framework

This chapter sets-out and discusses the conceptual underpinning of this research. It is divided into four broad sections. The first section presents one of the central conceptual links between science and technology studies and the social studies of finance, namely that markets, marketplaces, and market mechanisms are technologies to be studied and analysed in similar ways to more traditionally understood technological objects.

Accepting this position as a primary assumption of this research project, the next section presents some of the fundamental concepts developed for the study of science and technology in actor-network approaches. This section draws primarily from Latour's "*Science in action*" (Latour 1987), but also from "*Pandora's Hope*" (Latour 1999) and the work of Akrich (Akrich 1992), because of the way key ontological aspects of actor-network approaches are associated in these works with concrete questions relating to the work of scientists and engineers and how to study them.

Having established the basic concepts, the discussion then moves on to examine a central notion developed by Latour and Akrich (Akrich 1992, Akrich and Latour 1992, Latour 1992, 1993, 1996b), namely that technology can be analysed as a 'script' that sets-out a system or network of relations between human and non-human entities through a kind of material semiotics or "semiotics of machines" concerned with understanding the way that the articulations between these entities are made.

Finally, the way many of these notions, concepts, and assumptions have been adapted to settings concerned with the study of markets and market mechanisms is also presented and links with the particular research setting being studied in this research project are explained in the process.

Opening the black boxes of finance

Markets – especially financial markets – are entwined in complex webs of legal, fiscal, economic, administrative, technical, and other arrangements that "structure ownership, control, and exchange relationships in the economy" (Rauch and Casella 2001). They need to be treated and studied as actual spaces in which economic exchanges grounded in "ordinary experience" and enmeshed in webs of often messy material relations take place.

The extension of actor-network theory from science and technology studies to the study of economic activities undertaken by Callon in 'The Laws of the Markets' (Callon 1998b) results in a number of criticisms regarding the way markets have been conceptualised and studied in the past. These criticisms include the lack of attention given to the kind of physicality and materiality of markets and marketplaces outlined in the previous paragraph and the artificial separations that are assumed as existing between the actual economy and economic theory on the one hand and between economic and other activities on the other (Callon 1998b). In practice these pitfalls can be avoided, according to Callon, by undertaking a meticulous tracing of often taken for granted chains of interrelations that connect objects and subjects and of subtle relationships between economics and the economy and "between the market and the marketplace" (Callon 1998b).

This view, in essence, sees markets and marketplaces as forms of technological 'black boxes' to be opened and studied through empirical investigations of their internal mechanisms and the human and non-human elements that comprise them, as suggested by MacKenzie (MacKenzie 2005):

> "This paper advocates the application to global finance of one of the central heuristics of science studies: open the black box. Black boxes are devices, practices, or organizations that are opaque to outsiders, often because their contents are regarded as 'technical'. The goal of opening black boxes is to discover how they are kept opaque; how they structure their 'contexts'; and how those contexts are inscribed within them."[19]

[19] See (MacKenzie 2005, p.555)

The initiative by Euroclear to develop an integrated settlement system for securities transactions in the UK and Ireland, France, Belgium, and the Netherlands and being studied here is seen as a unique opportunity to study a financial market 'in the making'. Motivated by MacKenzie's exhortation and with a particular focus on the role of ICTs, the research has aimed to take advantage of this opportunity to study processes of financial marketplace black boxing, as suggested by MacKenzie (MacKenzie 2005, p.555).

The focus of this research is on central securities depositories (CSDs) – particularly the ICT platforms they employ – where titles to financial securities are held and ownership is transferred when trading or some other transaction take place. Settlement systems and the CSDs at their core occupy a central position in the complex sociotechnical networks that constitute securities marketplaces and are crucial in the framing of financial transactions and a key component in the constitution of financial marketplaces as "collective calculative devices" (Callon and Muniesa 2005). They have also been the loci for the development and operation of ICT systems that related to past fundamental marketplace innovation and reconfiguration initiatives, such as, for example, the 'dematerialisation' of securities [20]. Research attention has focused particularly on describing, understanding, and analysing the mutual shaping of human and non-human entities involved in the design and development of the common ICT-based securities settlement platform being developed and in particular those arrangements that aim to make possible direct transactions among counterparties across existing borders and exchange venues.

As will be discussed further on in the next section, it is at such moments of reconfiguration, during which black boxes are open, that it is possible to gain a better understanding of the way a marketplace is put together and of the reciprocal shaping of the human and non-human entities involved in the

[20] An account of dematerialisation in relation to the UK is included in Appendix E that describes the development of the CREST platform for the settlement of securities transactions. See also (Millo, Muniesa, Panourgias and Scott 2005, pp.237-238) for a brief discussion of the dematerialisation of securities in the USA and the establishment of the Depository Trust and Clearing Corporation (DTCC).

process. Furthermore, this particular setting also provides a chance to gain particular insights regarding processes of market integration, especially in relation to the role of ICTs in such undertakings.

Central research foci in actor-network studies of science and technology

Before moving to the specifics of the research setting being investigated, it is useful to outline some of the key concepts developed in actor-network approaches to science and technology studies, examine how the notion of the black-box and processes of black-boxing fit in with these, and what foci for empirical research these point towards.

Black boxing and studying technology in the making

As Latour writes in "*Science in Action*", "facts and machines in the making are always underdetermined" (Latour 1987, p.13), but once they become determined they also become what are referred to as black boxes, or as Latour sometimes also refers to as object-institutions (Latour 1999). This process of 'black boxing' is one of the key areas of empirical interest in science and technology studies.

In order to study "facts and machines in the making" it is important not to have any preconceptions, but, as Latour explains, to "watch the closure of the black boxes and be careful to distinguish between two contradictory explanations of this closure, one uttered when it is finished, the other while it is being attempted" (Latour 1987, pp.14-15).

The observer should not take at face value what scientists and engineers themselves *say* about what they do, because for them and the success of their work, black boxes have to remain closed. As Latour illustrates, most working scientists and engineers must rely on science and technology that are *already made* and not *in the making* (Latour 1987, pp.3-15).

The practical challenge for the researcher is to find ways of studying black boxes that need to be opened and that treat them as results rather than

explanations of a phenomenon. It is therefore important during the research process, to find ways to double-check independently, away from already ordered patterns of scientific and engineering method and rationality, both what scientists and engineers say, but also what they do (Latour 1987, p.15).

It is in situations of reconfiguration, as is the case with the research setting being investigated, that often submerged and stabilised objects re-emerge and the networks 'below' them become visible and observable. Analytically such moments are the most fruitful to investigate empirically (Latour 1987, Akrich 1992, Law 1992, Latour 1999).

It is in the controversies that accompany such reconfigurations that facts and machines and the processes leading to their stabilisation are unravelled and de-composed. As Latour writes in "*Science in Action*", "when we approach the places where facts and machines are made, we get into the midst of controversies" because, as disagreements grow, more and more black boxes are likely to be opened as there is always a point when local resources are not enough to open or close a black box and it is necessary to fetch further resources from other places and times using "texts, files, documents, articles, to help force others to change what was an opinion into a fact" (Latour 1987, p.30). Help is sought from higher, stronger, more important, or more numerous allies, the association with which must hold firm in order to resist trials of strength that ensue in the controversy (Latour 1987). Durability is thus imparted to the resulting object through obtaining the support of strong allies in the form of new links that tie instruments, figures, and texts both to each other and to the original claim being defended. In the process, movements from the conceptual to the material, from words into things, from the centre to the periphery, from the general to the particular, from the global to the local and then back again, ensue. Facts become statements, statements become facts, both can be incorporated into texts, objects, machines, automations, which can then themselves produce inputs and data that feed back into texts, statements, facts, and controversies.

Tracing the movements of actants, their transformations, and the things they fetch, recruit, seduce, convince and bring to the setting during controversies, has to be at the centre of empirical investigations of scientific and technological facts and artefacts (Latour 1987, p.15).

The initiative to develop a common settlement system for the trading of securities across five different marketplaces being studied here represents a moment during which the black box of a financial marketplace has to be opened, taken apart, and re-assembled. It is by following any resulting controversies and the transformations of the actants involved and the roles proposed for them in the new marketplace arrangement being developed up to the point at which the controversies are somehow resolved, that it becomes possible to study a marketplace in the making.

Actants, trials, and competences

A sociotechnical assembly holds together by dealing in some way with entities that conflict with the roles that it assumes for them. In the process, the resistances of the links and relationships that make up this network are tested against those of the recalcitrant sociotechnical entity. In fact, a sociotechncial network and the elements that comprise it are engaged in constant trials of strength and competence with other actants and entities that they are in contact with and their success and durability is linked to their ability to cope with such tests.

In such a light, the system designer is the author of a number of claims that must also withstand such tests if the proposed network is to hold together and *resist modification*[21]. New objects come into being and become stabilised by overcoming such trials and empirical effort needs to be directed at understanding such moments and processes of emergence in the particular settings being studied. It is out of such processes that new objects become

[21] The notion of resisting modification is of central importance in actor-network approaches to the study of science and technology because reality is seen as being what resists, what cannot be easily modified. Taking such a standpoint, reality and nature are seen as results rather than causes of science and facts and claims. Nature and reality appear retrospectively, with hindsight, once controversies are settled (Latour 1987, pp.93-99).

"things" and get black boxed (Latour 1987). As they become unproblematic and taken for granted, their trials are then forgotten.

New objects can gain by "importing" older ones in reified form and a genealogy of such objects can often be useful, both when disputing claims but also in tracing controversies. The older these 'imported' objects are, the 'harder' they will be. They form "sediments" of what has been going on in controversies earlier in time and elsewhere in space. Older objects are thus "capitalised" in instruments, practices, and disciplines (Latour 1987, pp.92-93). This point is indicative of why notions such as 'path dependency' and 'installed base' are seen as important in actor network theory.

It is by studying and understanding the mechanics and logistics, or as Latour writes, the "sociologics" of these processes that the construction of heterogeneous objects can be properly analysed and understood (Latour 1987, p.202).

Translation, delegation, and inscription

The key concern of the builder of such heterogeneous network is how to spread out his or her network as far as possible in time and space by having it associated with other networks (Latour 1987, Law 1992). To achieve this, one not only has to try and enrol other actants but to do so in a way that allows a certain degree of controlling of their behaviour. The paradox is that as more and more entities become involved, the more difficult controlling their modifications of the object being built becomes. The key notion of translation tries to address this paradox.

Translation is the interpretation given by the fact or technology builders of their own interests and those of the actants they seek to enrol in order to transform their claim into a matter of fact (Latour 1987, p.108). If translation is successful, the claim and the entities that are part of its building become indispensable to each other. Everyone "sits" in a particular place in relation to one another and facts, claims and objects flow uninterrupted in time and space. Every version of each actant's interest translates every other, and all together

acquire a "sort of hegemony" (Latour 1987, p.121). Their interests and goals become part of a black box. Others must be enrolled, believe in the proposed arrangement, buy into it, disseminate it across time and space, but, at the same time, also be controlled in order to ensure that what they borrow and transmit remains as far as possible unchanged (Latour 1987, p.121).

Black boxes are not just constructed in a one-off way, but have to be maintained. The entire network assembled is only as strong as its weakest link. If an ally "defects" or for some reason is not in a position to fulfil an envisaged role, replacements have to be found or some work-around put in place. The crucial thing is for the new set of associations to hold together as strongly – or more strongly – than the one being replaced.

Initially actants may be brought closer together, but tentative links have to be strengthened and the whole assembly bound more firmly together. Something is always needed to "tie the diverted resources and invested interests together in a durable way" (Latour 1987, p.122). The actants and their relations must be made predictable and crossing the boundary between humans and things can achieve this. As Latour writes, "the simplest means of transforming the juxtaposed set of allies into a whole that acts as one is to tie the assembled forces to one another, ... to build a machine". To do this, similar strategies to those used to interest and translate human actors in the case of fact building are used in order to enrol non-human actors also (Latour 1987, pp.128-129)[22].

Tracing links and relationships

One can analyse the story of a machine by looking at the changing shape of that machine in relation to the different people associated with it or by looking at the changing type of people linked to that machine (Latour 1987, p.138).

[22] As more allies and actors are recruited and have to be kept in line, however, the machine becomes more and more complex and it becomes just a question of who or what breaks down first. New mechanisms to oversee the existing ones are then developed, going from machine to automation. Each element must be made interested in the working of the others. This does not only apply to material things but can also be a system of pay or of detection of errors as much as a mechanical automation. Once again "a larger number of elements is made to act as one" (Latour 1987, p.131).

> "I have sought to offer humanists a detailed analysis of a technology sufficiently magnificent and spiritual to convince them that the machines by which they are surrounded are cultural objects worthy of their attention and respect. They will find that if they add interpretation of machines to interpretation of texts, their culture will not fall to pieces; instead it will take on added density. I have sought to show technicians that they cannot even conceive of a technological object without taking into account the mass of human beings with all their passions and politics and pitiful calculations, and that by becoming good sociologists and good humanists they can become better engineers and better informed decision makers".[23]

As Latour points out, "it is the same story viewed either from the standpoint of the enrolled people ... or from the enrolling things" (Latour 1987, p.138).

In general, any black box knits together a whole system of alliances, relations, and associations, both human and non-human. To study such a system, one has to look at whom it is designed to enrol and what it is tied to in order to make this enrolment inescapable. Both people and things are defined in relation to it.

> "Understanding what facts and machines are is as simple a task as understanding who the people [linked to them] are. If you describe the controlling elements that have been gathered together, you will understand the groups which are controlled. Conversely, if you observe the new groups which are tied together, you will see how machines work and which facts are hard. The only question in common is to learn which associations are stronger and which weaker. We are never confronted with science, technology, and society, but with a gamut of weaker and stronger associations; thus understanding what facts and machines are is the same task as understanding who the people are."[24]

Drawing from such an analysis, the issue of design can be seen as a strategy of ordering through enrolment and translation out of which a *system of relations* within which linked actants are located, is constructed[25]. To account for the many differences found among different chains of associations it is important to study:

---

[23] In (Latour 1996a, p.viii)

[24] In (Latour 1987, pp.140-141).

[25] This does not necessarily presuppose the existence of a designer or initiator of the design process although there is some conceptual leeway in actor network approaches for the existence of "centres of translation". As Latour writes, "we may call research the first moment and development all the work necessary to make the black box black, to turn it into an automaton that counts as one routine piece of equipment" (Latour 1987, p.169).

- The entities linked
- The strength and persistence of the linkages
- The existence of any intervening obstacles and how they are overcome

As agencies strive to make their claims more credible and build-up their networks, they "map for us and for themselves the chains of associations that make up their sociologics" (Latour 1987, p.202)[26]. The heterogeneous associations being assembled are revealed in the progression of the controversies generated along the way and can be studied by following whatever is tied to the claims made in them. The traces of the claims that circulate in the resulting networks are described as follows:

> "They are like road maps: all paths go to some place, no matter if the trails are tracks, highways or freeways, but they do not all go to the same place, do not carry the same traffic, do not cost the same to open or maintain. The only thing that is important is where they lead how many people go along them, with what sort of vehicles and how easy they are to travel on, not if they are right or wrong."[27]

The heterogeneous network builders "go from element to element until a controversy starts", and when this happens, "they look for stronger and more resilient allies, and in order to do so, they may end up mobilising the most heterogeneous and distant elements, thus mapping for themselves, for their opponents, and for the observers, what they value most, what they are most dearly attached to" (Latour 1987, p.205). It is possible, therefore, by tracing the unfolding of controversies, to gain an understanding of who the actants to be associated are and how their relations are modified during a controversy. The principle practical difficulty for a researcher in mapping such systems of heterogeneous associations is not to make any additional assumptions about the actants and their roles and relations (Latour 1987, p.205).

---

[26] Latour writes regarding the notion of sociologics: "Each of these chains is logical, that is, it goes from one point to the other, but some chains do not associate as many elements or do not lead to the same displacements. In effect, we have moved from questions about logic (is it a straight or distorted path?) to sociologics (is it a weaker or a stronger association?)" (Latour 1987, p.202).

[27] In (Latour 1987, p.205)

Immutable and combinable mobiles

The generation of immutable mobiles is closely linked to the development of *chains of reference* that are formed by the linking of actants and serve to make the physical world mobile and compatible with human systems of communication, and thus understandable to humans. The movements of these immutable mobiles traces the heterogeneous networks they are part of and can be of great value in their studying and observation. Events, places, people, things are made mobile while being kept stable "so they can move back and forth without distortion, corruption and decay", and be combinable so that they can be "cumulated, aggregated, shuffled, compared and used for calculations" (Latour 1987, p.223)[28]. A movement from things to signs and back again is thus made possible.

To ensure the stability of these mobiles, many material and institutional resources have to be brought to bear. Expeditions, probes, surveys censuses, are just some of the ways of doing this (Latour 1987, pp.224-227). Mapping can also be included in these and involves the linking of something already known to something that needs to be known so that a new chain of reference can be established.

The combinations and superimpositions of networks thus enabled can also lead to new understandings and propositions and ultimately new knowledge. Even in the case of so-called social sciences such as economics, new ways are being established to "transform whatever people do, sell and buy into something that can be mobilised, gathered, archived, coded, recalculated and displayed" (Latour 1987, p.227). All these can be shuffled around superimposed, recalculated and so on so as to end up with objects such as GNP, balance of payments, taxonomies, or even proven oil reserves (Latour 1987, p.227).

With ICTs, numbers, images, and texts from all over the world are transformed into the same binary code inside computers, resulting in the handling, the

[28] Once the accumulation of mobiles starts, those at the centre who were the most weak and blind to what was happening far away become the strongest as they can access many more places and times at once and with little effort. "Instead of the mind of the scientist revolving around things ... things are made to revolve around the mind" (Latour 1987, p.224).

combination, the mobility, the conservation and the display of such traces becoming dramatically facilitated (Latour 1987, p.228). What takes place, in effect, is what Latour calls, "the mobilisation of the world" (Latour 1987, 1999)[29].

Immutable mobiles can also change both time and space and make things from the past and far away close to hand. They show how space and time do not "exist independently as an unshakable frame of reference" inside which events occur, but instead how "different spaces and times might be produced *inside the networks* built to mobilise, cumulate and recombine the world" (Latour 1987, p.228).

With immutable mobiles, even if different levels and degrees of translations and representations are involved, reference holds throughout. This enables those at the top levels of these chains to speak with authority on behalf of thousands of other actors that may be in remote places and in different times (Latour 1987). New spaces are thus created, resulting in "new relations of distance and proximity" while "new neighbourhoods and new families are devised" (Latour 1987, p.236). Existing traces can thus be translated and something new gained. To understand these developments it is important to study and understand the logistics of these *immutable mobiles.*

Centres of calculation and the work of abstraction

Immutable mobiles are intimately linked to another key notion, that of *centres of calculation.* It is at centres of calculation inhabited by engineers and scientists that the sum of all mobilisations, evaluations, tests and ties in a network are visible, telling us what is associated with what and the nature of these relations.

[29] The strength of centres relative to peripheries is thus explainable without need for recourse to artificial divides between cultures, minds, or logic and rationality. At the same time, neither the centre nor the periphery can have any meaning without each other. No discipline can be constructed centrally in a universal and abstract way without reference to the local worlds out there and a familiarity with them based on the two-way flow of references between them (Latour 1987).

The "concrete work of making abstractions" that takes place in these centres of calculation is "impossible to understand apart from the mobilisation process" because they would then become theories that are "severed from the elements they tie together" (Latour 1987, pp.241-242). A whole chain of re-representations and cascades of inscriptions – that must also be studied – goes into the work of making abstractions. As long as this is always kept in mind, centres of calculation can be "more important to observe, study, and interpret than facts or mechanisms" because, by being at the heart of networks, they "draw all of them together" (Latour 1987, pp.240-241).

Theories and concepts are, in effect, the crossroads that allow those at centres of networks to manipulate, combine, rewrite and tie together all the traces obtained through the ever-expanding chains of associations they are at the heart of. But abstractions and theories must never be cut off from that which they are abstractions and theories of. Calculation can never be studied without studying both the centres of calculation, but also their links to the further reaches of the networks they are part of.

Furthermore, in such *centres of calculation* high-order re-representations can be combined with other high level representations in order to make new and unexpected connections between networks. References from previously totally unrelated realms are rendered in the same form and shape, enabling them to cut across vertical connections resulting from the cascades of rewriting taking place in particular chains of reference (Latour 1987, pp.244-245). A calculation on a piece of paper can apply to the outside world "only if this outside world is itself another piece of paper of the same format" (Latour 1987, p.251).

It is those at the centre who through their work design networks that are tied together in a few so-called *obligatory passage points*. The work of engineers, just as that of scientists, becomes to mobilise large numbers of allies, evaluate their relative strengths, reverse negative balances of forces, and try-out weak and strong associations tying together facts and mechanisms.

> "Machines are drawn, written, argued, and calculated, before being built. Going from science to technology is not going from a paper world to a messy, greasy concrete world. It is going from a paper world to another paper world, from one centre of calculating to another which gathers and handles more calculations of still more heterogeneous origins. The more modern they are, the more complex they are and the more paper forms machines need so as to come into existence".[30]

Towards a semiotics of technology

Having presented some of the key concepts of actor-network science and technology studies and the ontological concerns that inform them, this section now examines the implications these have in terms of how research settings viewed in such a way can be studied. Particular attention is given to the notion developed by Akrich and Latour (Akrich 1992, Akrich and Latour 1992, Latour 1992, 1993, 1996b) of technological objects as 'scripts' that assign actants roles and through the acting-out of which, a technology is performed. This was seen as having parallels with the work of the designers and developers of the settlement platform being studied and the way they went about assembling resources to build a working securities settlement platform.

So, what is involved in the study of the assembling of the kind of sociotechnical networks discussed in the previous section? Latour sums this up as follows:

> "So what is on its agenda? The attribution of human, unhuman, nonhuman, inhuman, characteristics; the distribution of properties among these entities; the connections established between them; the circulation entailed by these attributions, distributions and connections; the transformation of those attributions, distributions and connections, of the many elements that circulate and of the few ways through which they are sent."[31]

One approach to studying the development of sociotechnical assemblies comes from the transposition to the realm of technology, from semiotics, of concepts such as translation and articulation relating to how meaning is built (Akrich and Latour 1992, Latour 1992, 1996b). Central to such an approach are notions

[30] See (Latour 1987, p.253)
[31] In (Latour 1996b, p.374)

such as "programs of action"[32] that can be "inscribed"[33] into material entities. Like a script for a play or film, roles, actions, and attributes are assigned to both the human and non-human elements of a certain ensemble of heterogeneous actors (Akrich 1992, p.208).

The success of processes of assembling, delegation, and inscription comes about when these "actors" collectively "perform" the "script" and their "programmes of action" fit with those that the script anticipates for them. The job of the researcher is to "de-script" the various inscriptions and programmes of action embodied in particular sociotechnical arrangements (Akrich 1992, Akrich and Latour 1992, Latour 1992, 1993, 1996b).

Akrich in the electrification projects she describes (Akrich 1992, pp.214-215) provides an example of the conceptualisations of roles that certain inscriptions seek to impose on users, illustrating how concepts, abstractions, and institutions are also involved in the developing and allocation of programmes of action incorporated in the script of a particular sociotechnical arrangement such as an electricity network.

A key practical step for the researcher in such an approach is to identify, describe, and explain the relationships, associations, roles, actions, and attributes that a "script" assigns to both human and non-human actors as part of a "semiotics of machines" that helps one to understand and explain the processes of "moving from signs to things and back" (Akrich and Latour 1992, Latour 1992)

> "The aim of the academic written analysis of a setting is to put on paper the text of what the various actors in the setting are doing to one another; the de-scription, usually by the analyst, is the opposite movement of the in-scription by the engineer, inventor, manufacturer, or designer ... The de-scripton is possible only if some extraordinary event – a crisis –

[32] A concept derived from the notion of narrative programmes in the study of texts. As Latour writes, "each device anticipates what other actors, humans and non-humans, may do (programs of action), but these anticipated actions may not occur because those other actors have different programs ..." (Latour 1999, p.309).

[33] According to Latour, "a general term that refers to all types of transformations through which an entity becomes materialised into a sign, an archive, a document, a piece of paper, a trace" (Latour 1999, p.306).

> modifies the direction of the translation from things back to words and allows the analyst to trace the movement from words to things".[34]

Akrich provides a good example of how to do in practice empirical research into the study of the development of technological objects based on these assumptions and using these conceptual tools in "*The de-scription of technical objects*" (Akrich 1992).

Akirch takes an approach that sees machines and devices as "composite, heterogeneous, and physically localised" and part of "a long chain of people, products, tools, machines, money", the boundaries between which are "always hazy" (Akrich 1992).

Providing examples of how, many design choices are based on making assumptions and predictions regarding the way the technology will be used, Akrich argues that technology must be seen as "a product of complex compromises" between factors such as performance, legislation, law enforcement, values ascribed to different kinds of behaviours and so on that are folded and coded into technological objects (Akrich 1992, p.205).

> "... when technologists define the characteristics of their objects, they necessarily make hypotheses about the entities that make up the world into which the object is to be inserted".[35]

Designers, therefore, "define actors with specific tastes, competencies, motives, aspirations, political prejudices, and the rest and they assume that morality, technology, science, and economy will evolve in particular ways" (Akrich 1992). They *inscribe* their "vision of (or prediction about) the world in the technical content of the new object", with the end product acting like a "script" or "scenario".

> "Thus like a film script, technical objects define a framework of action together with the actors and the space in which they are supposed to act."[36]

---

[34] See (Akrich and Latour 1992, p.259)
[35] In (Akrich 1992, pp.207-208)
[36] In (Akrich 1992, p.208)

The technical realisation of the innovator's assumptions about the relationships between an object and its surrounding actors is thus "an attempt to predetermine the settings that users are asked to imagine for a particular piece of technology and the 'pre-scriptions' (notices, contracts, advice, etc) that accompany it" (Akrich 1992, p.208).

Seen in this way, technical objects "simultaneously embody and measure a set of relations between heterogeneous elements". They participate "in building heterogeneous networks that bring together actants of all types and sizes, whether human or non-human" (Akrich 1992, p.206).

> "If most of the choices made by the designers take the form of decisions about what should be delegated to whom or what, this means that technical objects contain and produce a specific geography of responsibilities, or more generally, of causes."[37]

The central focus of any enquiry, therefore, has to be to "describe the specific role [all these] play within these networks" and the way in which "they build, maintain, and stabilise a structure of links between diverse actants" (Akrich 1992, p.206).

The key is "to find ways of studying the conditions and mechanisms under which the relations that define both our society and our knowledge of that society are susceptible to partial reconstruction" (Akrich 1992, p.206). To do this "we have to move constantly between the technical and the social" and "between the inside and outside of technical objects" (Akrich 1992, p.206). Doing this, two vital questions start to come to the fore:

a) To what extent does the composition of a technical object constrains actants in the way they relate to both the object and to one another?
b) What is the character of these actants and their links and to what extent are they able to reshape the object and the various ways in which the object may be used?

[37] In (Akrich 1992, p.207)

Considered in this way, "the boundary between the inside and the outside of an object comes to be seen as a consequence of such interactions rather than something that determines it" (Akrich 1992, p.206).

> "The boundary is turned into a line of demarcation traced, within a geography of delegation, between what is assumed by the technical object and the competences of other actants."[38]

Taking such an approach, Akrich argues that it is also an important methodological issue to use a vocabulary that avoids inbuilt distinctions between the technical and the social and suggests for this purpose the "vocabulary of semiotics" (Akrich 1992, pp.206-207).

Akrich also identifies controversies as the central locus for research interest, seeing them as a way of finding the circumstances in which "the inside and outside of objects are not well matched" leading to disagreements, negotiations, and the potential for breakdowns that provide a good setting from which the elementary mechanisms of adjustment among the various actors can then be described (Akrich 1992, p.207).

While Akrich acknowledges that with regard to every object there is a "consensual zone", it is only around points of friction in "controversial zones", usually found around the margins, that "the battles leading to the establishment of supremacy of a certain design or solution are waged" (Akrich 1992, p.223).

The key steps that can be identified in the kind of research process presented by Akrich can be summarised as follows:

- Description of the distribution of competencies assumed when an object is conceived and designed
- Identification of the ways in which technical objects define actants and the relationships between them.

[38] In (Akrich 1992, p.206)

- Comparison of actual roles of the actants with those assumed by the designers
- Assessment of the obduracy of the objects in relation to the users

One fruitful approach suggested is to follow the negotiations between the innovator and the potential users and to study the way in which the results of such negotiations are "translated into technological form" (Akrich 1992, p.208). This provides an entry point for what Akrich calls "de-scription" and defined as "an inventory and analysis of the mechanisms that allow the relation between a form and a meaning constituted by and constitutive of the technical object to come into being" (Akrich 1992, p.209).

It is through de-scription that the processes through which "technical objects and people are brought into being in a process of reciprocal definition in which objects are defined by subjects and subjects by objects" can be revealed (Akrich 1992, p.222).

> "After the event, the processes involved in building up the technical objects are concealed. The causal links they established are naturalised. There was, or so it seems, never any possibility that it could have been otherwise. It is, therefore only after the event that we are able to say 'that objects do this and humans do that'."[39]

The next section will now attempt to link the concepts and approaches to the study of the assembling of sociotechncial networks outlined previously to the more specific setting of markets and marketplaces.

Studying financial marketplaces as sociotechnical assemblages

As the historical accounts of the emergence of financial marketplaces referred to in the literature review chapter show, in the past, the shared meanings, understandings, rules, norms, practices, and devices that constituted particular financial marketplaces were developed in an ad hoc way and through a shared need by market participants to deal collectively with practical problems and

[39] In (Akrich 1992, p.222)

challenges as much as by conscious design (Lane, Mueller and American Council of Learned Societies. 1985, Williams 1986, Padgett and Ansell 1993, Moser 1998, 1999, Padgett 2001). Through process of sedimentation or black boxing, many of these have become durable and coded into the shared physical, organisational, and institutional structures that have resulted.

Financial marketplaces can be considered, just like other technologies, as heterogeneous objects or sociotechnical networks defined by complex interrelations and the mutual shaping of human (individuals, collective entities, institutions, concepts etc) and non-human entities (devices, instruments, computers etc) out of which they are assembled [40]. The heterogeneity of the resulting assemblages and the complexity and interconnectedness of the entities that come together to form a financial marketplace and the degree of black boxing of concepts and technologies that give these marketplaces the durability and robustness to have become the leading centres of calculation that the most successful among them clearly are, make any effort at reconfiguration and redesign a difficult, but above all, collective endeavour, despite the much clearer orchestrating role marketplace operators now play.

It is out of such efforts to organise and order such elements, which may be social, technical, conceptual, institutional, textual, or whatever, that durable networks and objects such as financial marketplaces result. As Law writes, "society, organisations, agents, and machines are all effects generated in patterned networks of diverse (not simply human) materials" (Law 1992, p.380).

The success of this ordering can be limited by the properties or preferences of the elements – or actants – being assembled. Once this ordering process has been successful and the elements are "fitted together" (Law 1992, p.381), the network can be represented as an entity in its own right that forms the node of a new – higher-level – network. This node can then be described as an actant in

[40] Callon, Millo, and Muniesa propose the notion of 'market device' as "a simple way of referring to the material and discursive assemblages that intervene in the construction of markets"(Callon, Millo and Muniesa 2007).

its own right, with the underlying network of entities being "replaced by the action itself and the seemingly simple author of that action" (Law 1992, p.385). Such networks, therefore, order relations and interactions, but might equally break down or experience reconfiguration if the constituent links do not hold together well.

Tracing the emergence of these networks of relations and describing, understanding, and explaining the ordering of relations between human and non-human entities has to be at the centre of any enquiry into how devices, agents, institutions, or organisations are generated (Law 1992), and this can be extended to heterogeneous objects such as financial marketplaces.

The heterogeneous object being studied, in this case a securities settlement system, defines a whole set of relationships between human and non-human entities that participate in a such a marketplace, but, at the same time, is also defined by all the actants that are linked to it and by it and that thus make it up. A new heterogeneous object is being proposed as a replacement (extension?) to existing settlement systems and this transition will require a great number of translations, new delegations, modifications to existing chains of reference, transaction flows, and inscriptions. A central empirical concern of the research therefore has to be to trace such changes through time, materials, and space, but also in terms of roles and reconfiguration of relations that this transition entails.

In the sections that follow, having illustrated how a number of the key conceptual devices of actor-network theory discussed previously in the chapter are also relevant in a market setting, attention will focus on the specifics of securities markets and settlement systems.

Securities and the mobilisation of the world

A number of the fundamental concepts developed in actor-network approaches to the study of science and technology and discussed in the first part of this chapter such as inscription, chains of reference, immutable mobiles, centres of

calculation and the linking of people and things also prove useful in studying the establishment, functioning, and growth of financial securities marketplaces.

It is through such chains of reference, for example, that the local, material, and practical realities of working businesses and their financial and capital needs are linked, through the inscription of ownership and obligations into titles and other processes of textualisation, standardisation, compatibility, and then circulation through networks of devices, mechanisms, and agencies, to the increasingly abstract worlds of investors, trading, financial exchange, and calculation. For such claims and obligations to flow backwards and forwards and around such a network in an uninterrupted way and maintaining their integrity, the circuit must be complete and unbroken and the roles and functions of all the elements participating in this circuit must be well defined and stabilised in relation to one another.

Barron's "Dictionary of Financial and Investment Terms" defines a security as follows:

> "Instrument that signifies an ownership positions in a corporation (a stock), a creditor relationship with a corporation or government body (a bond), or rights to ownership such as those represented by an option, subscription right, and subscription warrant".[41]

The implication of this is that a set of relationships pertaining to the allocation of rights and obligations to certain productive resources is framed in a particular way and then inscribed into a certain material entity. For example, share certificates – standardised and legally specified and recognised paper documents – entitle the holder to a particular fraction of the company, its assets, profits, and decision-making powers[42].

---

[41] In (Downes and Goodman 1998)

[42] Stocks and shares are part of the historical innovation of the joint-stock company. This allowed the development of corporate entities as separate legal persons. Ownership, control, and governance of the corporate entity were through the holding of securities entitling the holder to a particular fraction of the company, its assets, profits, and decision-making powers. These certificates are part of a chain of mobilisation of economic assets that makes possible their easy exchange and circulation. A certain proportion of the ownership of an economic entity is inscribed into them and this inscription links the certificate to the laws and regulations that govern the ownership and operation of economic entities such as corporations. This, in turn, confers on the holder of the certificates certain property rights and responsibilities

Such certificates – whether physical or not – are part of a chain of mobilisation of economic assets that makes possible their exchange and circulation. In the case of shares, a certain proportion of the ownership of an economic entity is inscribed into the certificate. This inscription links the certificate to the laws and regulations that, in for example the case of stocks and shares, govern the ownership and operation of legal economic entities such as firms. This, in turn, confers on the holder of the certificates certain property rights and responsibilities regarding the economic assets thus mobilised that flow from these legal arrangements specified in company law.

In this way, ownership of fixed and locally entangled economic assets becomes mobilised and exchangeable. This provides a stable and reliable context in which objects and obligations are clearly mapped out and intersubjectively recognised and which is crucial to the calculative aspects of a market being enabled (Slater 2002, p.238). As a result, it is possible for the trading of these titles of ownership to become organised, structured, institutionalised, and concentrated in specific venues, under particular rules and regulations, and according to certain practices[43].

A settlement system is an important component of such a circuit that allows claims to assets to flow from the reality of businesses on the ground needing to raise capital, to investors, and then to the financial markets on which these investors trade these claims and then back to the operation of the businesses on the ground. It is a sociotechnical expression of the laws that give rise to securities as "materially and conceptually disentangled" transactionable objects

---

regarding the economic assets thus mobilised and that flow from these legal arrangements, with company law specifying, in a general way, how the share capital of a company relates to the legal form that a company adopts.

[43] A number of historical accounts describe the links between the standardisation of the stock transfer procedure and the early development of the London Stock Exchange. It can be seen in a description of the work of a broker from 1707 as quoted by Duguid (Duguid 1901, pp.22-23): "If I am minded to buy two shares in East India Stock, I speak to a broker if he knows of any to sell, he enquires and finds one that will sell two shares, which he buyeth for me at the Price current on the Exchange, and when the same are transferred to me in the Company's Books, I pay for them". Also Mirowski, (Mirowski 1981), quoting P.G. Dickson (Dickson 1967, p.460), describes how "the main features of the form of stock transfer were already settled in the 1690s" and "remained as standard procedure for most of the following century", before the actual institution of the Stock Exchange in 1772.

(Slater 2002, p.238) and also specify how their circulation and exchange is organised and performed. As such, it formats the connections between transacting parties and the inscriptions being transacted, by specifying the characteristics they must both have for an easy and problem-free attachment and detachment between them to take place and stipulating the processes that must be followed for the claims involved to hold throughout the interaction.

As can be seen, exchange and circulation are as important to the mobilisation of fixed local economic assets as the inscription of property rights into certificates. Mechanisms that enable the easy and problem-free detachment and attachment of exchange objects from the world of one transacting party to that of another are needed (Callon and Muniesa 2005, pp.1232,Millo, Muniesa, Panourgias and Scott 2005, p.231). Stable legal entities and frameworks are necessary for reliable and predictable exchange encounters to take place (Slater 2002, p.238). Buyers and sellers have to be established as "individual socio-legal entities, such that property has a clear initial and final owner" (Slater 2002, p.238).[44]

The following example of a generic share transfer process for equities will help to illustrate these points in a more concrete way. Shares in a company are recorded in a register of shareholders. In the case of registered – as opposed to bearer – shares, the numbers of the certificates allocated to particular holders is kept and amended accordingly if shares are transferred or the shareholdings are somehow altered for whatever reason. If the original shareholders decide to bring in a new investor or participate in a merger or want to sell their part of the company, transfers, sales, or new issues of shares are likely to be involved and this would be reflected in the share register of the company, with existing numbered shares being entered under the name of any new investors that join the group of existing shareholders or new shares added to the register if the share capital is increased[45]. This is the way what is known as 'book entry

[44] All these points are illustrated in more detail in relation to stocks and shares in Appendix C, where the links between the constitution of securities and the securities settlement system are also further elaborated.

[45] In the UK, until the introduction of the CREST ICT-based settlement system in 1996, the Stock Transfer Form sent to a company's Registrar represented the only means of transferring

transfer' is effected, which refers to the amendment of a registry of shares, or 'book', by changing the name of the holder in the registry – or 'book' – from that of the seller to that of the buyer, thus amending the 'book entry' for that share certificate. When the shares have also been 'dematerialised', that is, structured electronic data entries in a legally recognised and authorised computer system have replaced paper certificates as titles to ownership, the 'book' is replaced by a database with tables for members and tables for shares, with the field for the owner of a certain share being changed in order to reflect the transfer of ownership. The conclusion of a transfer of securities from a seller to a buyer through a 'book entry' at a central securities depository (CSD) is effected when what is known as delivery versus payment (DvP) takes place (i.e. the simultaneous movement of the titles being traded from the account of the seller to that of the buyer and the agreed payment from the account of the buyer to that of the seller).

With the involvement of ICTs in general, and the ICTs at the heart of the clearing and settlement systems of financial marketplaces in particular, the inscriptions and complex chains of reference that make possible the trading and exchange of highly-entangled and often immobile assets can operate at the volumes and speeds seen now. Without some kind of re-articulation, however, the unbroken chains of reference between lender and borrower still breaks down across different jurisdictions.

For this entire chain to hold during a transaction across marketplaces and jurisdictions, a re-articulation of the interactions involved needs to take place through the reconfiguration of the heterogeneous network of human and non-human elements that hold this chain together. Only when this new circuit is completed and the claims and obligations – the circulation of which trace the boundaries of the existing local marketplaces – still hold across borders and

---

legal title and it is still used today for transfers of the remaining paper titles still in circulation. Before the introduction of CREST in the UK, the Registrars operated a distributed share registry system for the shares of companies traded on the stock exchange, but in other jurisdictions, a central registry or depository of shares eligible for trading on the stock market was instituted, with certificates available for trading on the stock exchange 'immobilised' in such Central Securities Depositories (CSDs) and simply moved from the account of one member to that of another as a transaction took place. This is known as 'book entry' transfer.

marketplaces, will a new wider common transactional space within which the same claims and obligations still hold and circulate, have come into being.

It is by following the processes of coding the transformation of relations between actants involved in the re-configuration of the existing securities marketplaces into the ICT platform being developed in order to make possible transactions across jurisdictions, that the tracing of the transformation of these chains of reference and mobilisation so that they hold across jurisdictions can be undertaken.

Making economic assets calculable

One of the important consequences of the extension of science and technology studies to the study of economics and the economy is a recasting of the concept of calculation based on a broader understanding along the lines proposed by Latour in "*Science in Action*" in relation to the notion of "centres of calculation" (Latour 1987, pp.233-257).

This was seen as a way of overcoming what were seen as artificial separations between economic and non-economic action and oppositions "between quantitative and qualitative aspects" of calculation (Callon and Muniesa 2005, p.1230), described by Callon and Muniesa as follows:

> "Whereas economics maintains the idea of a reality of 'pure' calculation, the other social sciences try, by contrast, to show that real practices are infinitely more complex and leave little room for calculative practices per se".[46]

The notion of calculation proposed instead moves beyond a definition restricted to "performing mathematical or even numerical operations" to one much broader that sees calculation as "establishing distinctions between things or states of the world, and ... imagining and estimating courses of action associated with those things or with those states as well as their consequences" (Callon and Muniesa 2005, p.1231).

[46] See (Callon and Muniesa 2005, p.1230)

For such calculation to be possible, a finite number of entities to be taken into account have to be detached from their setting and moved to a "single space" where they are arranged, ordered, compared, and manipulated according to some common operating principles and a certain result eventually extracted (Callon and Muniesa 2005, p.1231).

> "A new entity must be produced (a sum, an ordered list, an evaluation, a binary choice, etc.) that corresponds precisely to the manipulations effected in the calculative space and, consequently, links (summarizes) the entities taken into account".[47]

This recasting of the notion of calculation has important consequences for the conceptualisation and study of markets and marketplaces.

It becomes of central importance to describe the "arrangements that allow calculation", as defined above, to be performed (Callon and Muniesa 2005, p.1232). This also opens up a whole new area for empirical investigations that reconcile the "calculative character" of markets with the "detail of ethnographic description" found in empirical examinations of actual concrete marketplaces (Callon and Muniesa 2005, p.1230) and through which the elements that must be brought together in order for markets to be able to "behave as calculative collective devices" (Callon and Muniesa 2005, p.1230) can be elucidated.

As has been shown in the previous sections, in the trading of securities much effort and work must go into making concrete economic assets calculable and transactionable and the settlement system, linked to both the constitution of securities as calculable objects of exchange and the "organizations that allow for a calculated exchange and a market output" to take place (Callon and Muniesa 2005, p.1230), is a central part of these arrangements.

[47] See (Callon and Muniesa 2005, p.1231)

The settlement system and the framing of securities transactions

As is demonstrated by the discussion so far, the rules, processes, and devices that constitute a securities settlement system are a key component in the framing of securities transactions by contributing to the organisation of "the encounter between calculative agencies and calculable goods" in such a way as to make a "calculated exchange possible" (Callon and Muniesa 2005, p.1230). The settlement system in securities trading is a vital sociotechnical mechanism, or 'market device' (Callon, Millo and Muniesa 2007), that makes possible the easy and problem-free detachment and attachment of exchange objects from the world of one transacting party to that of another (Callon and Muniesa 2005, p.1234) by providing the stable legal entities and frameworks necessary for reliable and predictable exchange encounters to take place (Slater 2002, p.238).

It is at the level of the settlement system of a particular financial marketplace that *what* can be exchanged by *whom*, and *how* a transaction must be organised in accordance with the relevant laws and regulations so that property can have "a clear initial and final owner" (Slater 2002, p.238), is set out. It defines clear entry and exit points to that frame and the circumstances under which entry and exit can take place.

In this way a social space (Callon and Muniesa 2005, p.1243) or, in the words of Akrich, a "geography of delegation" (Akrich 1992, p.206) is outlined that is not confined to the inside of the settlement platform, but extends to the organisation of the interlinking of securities trading activities with other parts of the broader financial system, such as, for example, the payments system that makes possible payments among market participants in exchange for the sale of securities [48].

Settlement systems can be viewed as scripts, in the sense proposed by Akrich (Akrich 1992), for the heterogeneous networks they are at the centre of and that

[48] The points made above are illustrated in Appendix D in a generic description of the role of clearing and settlement entities in relation to transactions on an organised securities marketplace such as a stock exchange.

they link to one another. As such, they can be treated as a kind of definitional repository for the particular settings and the roles of the actants that participate in them[49]. The various articulations and transformation that need to take place to go from the material reality of working businesses, to property titles, to investors, to trading, and to the increasingly abstract and virtual world of speculation can be seen, identified, and read-off from these arrangements.

It is a key challenge for any attempt to develop a cross-border marketplace for securities, to find a way of dealing with the jurisdictional boundedness of securities as exchange objects that results from their entanglement in all these techno-legal arrangements. Studying how this can be effected in practice and what the role of ICTs is in developing concrete mechanisms to do so are central areas of interest for the research project. This, in turn, will shed light on broader issues of how the encounter between calculative agencies and calculable goods is organised in securities marketplaces in practice, how these are linked and shape each other, and what takes place when the integration of different such arrangements is undertaken.

Looking at the integration of financial marketplaces from the point of view of the literature that has emerged from the extension of actor-network approaches to science and technology studies to the realm of economics and markets, new spaces of exchange and calculation are not simply brought about through the linking of previously separate transacting parties without the appropriate arrangements that make calculability and transactionability possible also being in place.

The initiative to develop a cross-marketplace and cross-jurisdictional securities settlement system being studied here presents an opportunity to identify what the elements that need to be brought together for a securities marketplace to be able to function as a new and expanded "calculative collective device" are and

[49] This can be seen in practice in Appendix D that outlines the general functions of a settlement system in relation to transactions on a financial exchange, but especially in Appendix E, where in the description provided of the CREST settlement system in the UK and which draws from the operational manual of the system in which the 'roles' for the various entities that participate in the system and the functions they need to perform could be read-off the manual in a way that was reminiscent to a script for a play or screenplay for a film.

how this bringing together takes place so five disparate existing calculative spaces can be integrated into a single space that organizes "the encounter between calculative agencies and calculable goods" (Callon and Muniesa 2005, p.1230).

Summary

Staring from the basic premise put forward by MacKenzie that markets and marketplaces can be treated as the technological 'black boxes' of science and technology studies to be opened and studied through empirical investigations of their internal mechanisms and the human and non-human elements that comprise them (MacKenzie 2005), this chapter has attempted to show how some of the key concepts and research concerns of actor network theory developed in relation to studies of science and technology could be applicable to the study of financial securities marketplaces.

The concept of the 'black box', the reasons for its importance in actor network theory and the implications of such a conceptualisation in terms of how black boxes might be studied were then discussed, with particular emphasis on the role of controversies and the trials through which they eventually get resolved. It was then argued that the initiative to develop a common settlement system for the trading of securities across five different marketplaces in different jurisdictions being studied, represents a moment during which a number of securities marketplace black boxes have been opened, taken apart, and re-assembled and that it is by following the resulting controversies and the transformations of the actants involved and the roles proposed for them in the new marketplace arrangement that it becomes possible to study a marketplace in the making.

The discussion then moved on to the notion of the resolution of controversies through trials of durability out of which new stable objects emerge. As a sociotechnical network expands by coalescing with other larger or smaller sociotechnical networks, sooner or later a point of contact is reached where there is a conflict of scripts between the actor networks involved. By

overcoming such conflicts and absorbing more entities along the way and holding them in place successfully, a sociotechnical network gains in durability.

Tracing this expansion and understanding how it is achieved is a central aim in actor network theory studies. By tracing the unfolding of controversies and their resolution through trials, it is possible to gain an understanding of who the actants to be associated are and how their relations are modified during a controversy. It was then argued that the designers and developers of the cross-border settlement system being studied here could be considered as network builders that assemble heterogeneous elements. When a controversy results, they need to either assemble additional entities that will help them overcome the resistances to their allocation of roles from any recalcitrant entities or modify their initial roles for those entities in order to accommodate them. In the case being studied, external specialists or a ICT new device may need to be recruited to resolve some difficult technical problem, or political lobbyists hired and media campaigns launched to ensure that some legislative or regulatory obstacle is removed.

The importance of what are referred to in actor network theory as 'immutable mobiles' was then examined. Because actor networks are assemblies of human and non-human entities, the movement from things to signs and back again is crucial in terms of making the physical world compatible with humans and their systems of communication. This movement takes place through chains of reference along which immutable mobiles can travel that make people, places, and things movable while keeping some of their key characteristics stable. This notion was found to be particularly pertinent to securities marketplaces as, it was argued, securities could be seen as participating in chains of reference through which local and fixed economic resources could be mobilised, rendered comparable, aggregated, shuffled, combined, evaluated, and exchanged from a distance in financial marketplaces, or what are referred to in actor network theory as 'centres of calculation' where the work of abstraction takes place.

Having discussed some of the key tenets of actor network theory and how they may relate to the study of securities marketplaces, the chapter also examined the notion of technological objects as 'scripts' proposed by Akrich and Latour as part of a 'semiotics of technology' through which the connections and associations of actor networks can be analysed, with the researcher aiming to identify and describe the relationships, roles, actions, and attributes that a "script" assigns to human and non-human actors and explain how these stabilised into more durable structures.

In the next chapter the way the conceptual concerns discussed in this chapter have been translated into a practical research project and the details of the empirical material used and the way it was chosen, collected, and processed is presented.

Methodology

In the previous chapter the conceptual links between actor-network studies of science and technology, markets and marketplaces, and the specific setting being investigated in this research project were presented. This chapter explains how an actual empirical study based on such an approach and informed by the concepts and concerns outlined previously has been attempted in practice.

One of the primary practical concerns in the design of this research project and one that influenced the adoption of an approach informed by actor-network science and technology studies had been the heterogeneity encountered in this particular setting and how to deal with it and the lack of clear boundaries it results in. By treating humans and non-humans symmetrically as elements in an intertwined assembly of entities, without privileging or taking for granted either of the two in accounts and analyses, actor-network approaches to the study of science and technology were seen as being particularly well-suited to dealing with this setting.

As discussed previously, in order to maintaining this balance between human and non-human entities advocated by such approaches, it is necessary to concentrate on studying, describing, understanding, and explaining the links, relations and associations between actants, the way these are established and brought together, the logic that underpins them, and how they persist or change over time, leaving all other "ready-made" concepts and theories outside the analysis.

The notion of technological scripts that define "geographies of delegation" by proposing particular roles and competences for the various constituent elements of a technological setting put forward by Akrich (Akrich 1992) and discussed in the previous chapter, provide a good way of going from these more ontological concerns to analysing actual sociotechnical settings.

Such 'scripts' can be seen, both in the existing securities settlement systems to be integrated by the Euroclear initiative being studied and at the heart of the process of design and development of the Euroclear cross-marketplace settlement system[50]. Through the process of development of the common securities settlement platform being assembled by Euroclear, the new script being proposed goes through a series of rewrites, modifications, translations, and material shifts before the intended performance can come together as a whole. This 'script' inevitably includes a number of assumptions and conceptualisations relating to the roles that all entities – including ICTs – will have to play in the proposed new arrangement. During the processes of modification and translation that take place before a stable configuration is reached, these roles go through a number of changes as the interests and goals of other actants are accommodated and their requirements, particularities, and competences are taken into account.

The new object will hold together and be performed if all the entities involved, both human and non-human, fulfil the roles the proposed configuration assigns to them. In order to arrive at this point, different conceptualisations and configurations of the roles of the entities that will constitute it have to be proposed, refined, tried, and translated until a viable arrangement is arrived at. Only when all the entities assume their proposed roles and are able to hold together and perform these roles in a trouble-free way will the cross-marketplace and cross-border transfer of legal title to securities become a reality.

A key practical step for the researcher taking such an approach is to 'de-script' the script written into a technological object "by the engineer, inventor, manufacturer, or designer" (Akrich 1992, p.259). In such a process of 'de-scripting', "the aim of the academic written analysis of a setting is to put on paper the text of what the various actors in the setting are doing to one

[50] It is a central methodological assumption of this research that the notions of scripts, programmes of action, and inscription proposed as part of a "semiotics of machines" (Akrich 1992, Akrich and Latour 1992, Latour 1992, Latour, Mauguin et al. 1992, Latour 1993, 1996a) can be extended to the setting being researched here.

another", to identify, describe, and explain the relationships, associations, roles, actions, and attributes that the 'script' assigns to both human and non-human actors in order to understand and explain the processes of "moving from signs to things and back" (Akrich and Latour 1992, Latour 1992).

By focusing on the relationships and interactions between actants and their syntaxes and articulation and how these might succeed – or not – in stabilising and reproducing themselves rather than the properties of actants, limiting and potentially distorting reductionist assumptions are avoided.

This very specific epistemological and methodological requirement of actor-network science and technology studies, that analytic attention should be tightly focused on the associations between human and non-human entities, is firmly linked to the ontological assumptions, such as the rejection of a separation between the mind and the physical world, that underpin such approaches and which are discussed in more detail in the literature review chapter. Latour writes about this:

> "AT ... is a method to describe the deployment of associations like semiotics is a method to describe the generative path of any narration. It does not say anything about the shape of entities and actions, but only what the recording device should be that would allow entities to be described in all their details. ... When it says that actors may be human or unhuman, that they are infinitely pliable, heterogeneous, that they are free associationists, know no differences of scale, that there is no inertia, no order, that they build their own temporality, this does not qualify any real observed actor, but is the necessary condition for the observation and the recording of actors to be possible. Instead of constantly predicting how an actor should behave, and which association are allowed a priori, AT makes no assumption at all, and in order to remain uncommitted needs to set its instrument by insisting on infinite pliability and absolute freedom."[51]

This has important implications in terms of designing an empirical research project and constrains the approaches to data collection and interpretation that the researcher can deploy, as acknowledged by Latour:

[51] See (Latour 1996b, p.375)

> "In order to map the development of ... a technical innovation, the STS field has learned to doubt the dichotomy between nature, on the one hand and society, on the other. ... Alternative narratives have been developed under the heading 'actor-network theory' that stress the heterogeneity and variability of associations of humans and non-humans. Unfortunately, they are themselves made difficult to grasp because of the alternation between social interpretation, that seems to reduce the content of science to a purely strategic show of force where might makes right, and a naturalistic interpretation that appears to grant back to non-humans the unproblematic presence of nature".[52]

The solution proposed by Latour in order to overcome this problem is to propose a kind of semiotic analysis of technologies (Akrich and Latour 1992, Latour 1992, Latour, Mauguin and Teil 1992, Latour 1996b). A central practical concern of such an approach is to identify the number of entities associated together by a particular conceptualisation of a technological object, or script, and then traces the transformations that the proposed arrangement undergoes in order to associate more entities and gain in durability and acceptance[53]. In this way, the different degrees of acceptance that successive versions of the proposed arrangement encounter, can be seen (Latour, Mauguin and Teil 1992, p.35). This mapping allows the researcher to define a technological object as "a series of transformations – or translations – undergone by a collective of people and things" (Latour, Mauguin and Teil 1992, p.34). Once a cluster of actants "stay together through successive versions without defecting", they can be "aggregated into a black-box" that is given its own name (Latour, Mauguin and Teil 1992, p.41).

The design of the research has had to focus, therefore, on how to trace links and associations and untangle the complex web of relations and articulations of elements such as institutions, ICTs, devices, calculations, transformations, property rights, money, contracts, information and so on that need to be in place for a cross-border securities marketplace to exist and function. Through a decoding of the syntaxes, grammars, and semantics of these articulations that constitute this object, a semiotics of technologies, as suggested by Latour (Latour 1992, 1996b), has been attempted, as will be outlined below.

---

[52] See (Latour, Mauguin and Teil 1992, p.33)

[53] The analysis proposed in only interested in the existence or not of an association among actants, with "no attempt at qualifying the relations between units".

Translating an actor network research approach from words into a concrete research project

The three central tenets that the design of the empirical investigation has been based on are the following:

a) The artificial separation of object and subject should be avoided in favour of human and non-human entities that mutually define each other
b) Notions of 'the social' as relations exclusively among human actors should be rejected in favour of an approach that sees the social as a collective of human and non-human elements or actants
c) Only links, associations, chains of references, and articulations among actants that can be traced through time and space are valid research foci

The central focus of the empirical investigation, therefore, is to describe, decode and explain the complex interrelations between people, things, ideas, concepts and other such elements that are being assembled in the development of an integrated securities settlement system for five different securities marketplaces and to see and understand how these elements are put together, how they are positioned in relation to each other, in short, how they are *articulated.* In other words, to understand the particular *syntaxes* and *grammars* of these linkages and their *logic* and the way they enable the whole network to hold together in a durable way. Only then can the success or failure of these *heterogeneous assemblies* be understood in their own terms and the reasons for their persistence, stabilisation, development, or change be properly grasped and understood (Latour 1987, Law 1992, Latour 1999).

As explained previously, central foci for the empirical research being undertaken have been:

- How the various actors and their roles are defined around the new heterogeneous object of a cross-border securities trading settlement system

- How, in turn, these initial roles and the initial conceptualisations they are based on are modified through the various translations until stabilisation is reached
- How is this stabilisation achieved and what can be said from this about the design and development of ICT-enabled financial market infrastructures?

As already stated, the central aim of the research is to study the design and development of a common settlement system for the trading of securities across five different existing and jurisdictionally separate marketplaces. This is done through the describing and explaining of the roles of the actants involved in this process and the processes and mechanisms through which the transformation of relationships and links between these actants, both human and non-human, take place until enough stabilisation can be achieved and a new sociotechnical object, the cross-border settlement system, takes shape.

From such a perspective, design can be seen as a process of enrolment, translation, mobilisation, and inscription, while development can be seen as a series of trials of competencies and strength on the way to stabilisation occurring and the circulation of references and facts that will hold together the entire network taking place in an uninterrupted way. For this to happen controversies, doubts, and malfunctions must have been resolved.

To do this in practice, the research design focused on analysing this particular sociotechnical assembling initiative through a tracing of the struggle involved in the development of this system among the designers and developers and the actants to be assembled around the roles proposed for the actants in the designers' scripts. As this struggle unfolds, moving from conceptualisation, to the drafting of business plans, the merger of corporate entities, consultations with market participants, and the development of ICTs, the changes to the inventory and roles of the actants to be brought together were traced and particular controversies relating specifically to ITC components of the sociotechnical network being assembled were focused on all the way through

to the choices made to resolve these controversies and bring about a stabilisation of roles and relationships.

The role of texts and documentation

The primary entry point to the research setting has been the consultative and other project-related documentation assembled during the course of the design and development of the common ICT-based settlement platform being studied as well as a number of technical manuals and terms and conditions documents[54].

The "key role of document production (both electronic and paper-supported)" observed in modern economic life have made the study of documents in such settings a focus of academic research in recent years (Preda 2002, p.208)[55]. This is part of a more general recent growth in interest in approaches to the study of financial and economic activities that pay particular attention to the technicalities and materiality of finance and grouped under the social studies of finance research agenda (Preda 2002, Callon and Muniesa 2005, MacKenzie 2005, Millo, Muniesa, Panourgias and Scott 2005, Beunza, Hardie and MacKenzie 2006, MacKenzie 2006).

Some such studies of documents have been concerned more with "business efficiency and smooth communication flows" and the relationship of documents to "improving productivity and organizational learning" (Preda 2002, p.208). Other approaches have been more concerned with "accounts and account legers" and how they not only "register and document business transactions, but also organize economic realities, reduce uncertainties about the outer world, and create routines – that is, stable paths of economic action" (Preda 2002, p.209). Preda writes about this:

> "... research on documents in economic and financial settings has until now emphasized their role as information carriers and as formal organizational instruments. The question of how this production itself

[54] A list is provided in Appendix B

[55] This is by no means a recent development in the broader field of the studies of science, scientific practices, and the production of scientific knowledge. See (Galison 1987, p.x).

> acts as an organizational device has not been studied in detail. More specifically, how does economic and financial knowledge structure economic action? To what extent does its production shape relationships between economic actors? How is action-relevant information constituted, and what does this mean? ... These are questions that cannot be completely and satisfyingly answered with the argument that texts and economic documents simply mediate and organize external information about economic phenomena".[56]

Drawing from an empirical study of the production of document such as research reports, analyses, and newsletters in several European banks, Preda proposes that documents in such settings should be seen as "organizational devices, with the help of which relationships are created, maintained, and managed across various contexts" and in which "financial action is embedded" (Preda 2002, p.208).

Texts and documents also have a central role in actor network studies, but not in the conventional sense found in approaches based on textual, content, and discourse analysis, but closer to the one proposed by Preda, as actants in their own right participating in the formation of sociotechnical assemblies through the "transfer of skills and knowledge across various contexts ... making action at a distance possible, and ... bringing human actors together into a cognitive network" (Preda 2002, p.214).

Moving away from finance, but staring from a similar point of departure, Cooren proposes that the study of organizational settings in general would be significantly enhanced through approaches that "focus explicitly on the agency of organizational texts" (Cooren 2004, p.374). Cooren sees texts such as reports, contracts, memos, signs, work orders and so on as making active contributions to organizational processes, by participating in the stabilization and repeatability over time of activities (Cooren 2004, p.374). A central element of Cooren's position is that the general reluctance to acknowledge the agency of non-human entities is a consequence of the blurring of the distinction between the notions of 'action' and 'intentionality', illustrating this by pointing out how "we speak of 'action of acids on metals'" (Cooren 2004, p.376).

[56] In (Preda 2002, pp.209-210)

Instead, Cooren suggests, the term 'action', should be restricted to referring to "the production of some kind of change", "a transformation of state operated by an agent" (Cooren 2004, p.376). Cooren's position on the agency of texts, which is echoed in the design of this research project and the way documents are used to study the research setting being investigated, is summed up in the following passage:

> "The textual agency approach suggests that what constitutes an organization is a hybrid of human and nonhuman contributions. Signs, memos, and contracts display a form of agency by doing things that humans alone could not do. Created by human beings, these texts participate in the channeling of behaviors, constitute and stabilize organizational pathways, and broadcast information/orders. ... By *remaining*, these textual agents fabricate relatively fixed spaces and times; they define objectives; they forbid specific behaviors; and they invite or enforce humans to follow specific organizational pathways."[57]

Cooren's approach to textual agency builds on the central notion of actor network theory, that agency is distributed in heterogeneous networks consisting of human and non-human entities. To understand the role of texts and documents in actor network theory and the study of technosciences, it is important to delve further into the adaptation and adoption of the tools of semiotics, developed for the study of meaning, to the study of sociotechnical assemblies through a *semiotics of machines* or a *semiotics of technology* as proposed by Akrich and Latour (Akrich 1992, Latour 1992, 1996b).

Semiotics is described by Latour as a "necessary step" in the study of sociotechnical assemblies because when one brackets-out "the question of reference and that of the social conditions of productions - that is Nature 'out there' and Society 'up there' - what remains is, in a first approximation, meaning production, or discourse, or, text" (Latour 1996b). Although this entails an acceptance of many of the premises of semiotics, it also represents a move in analysis away from the limitations of studying language use and texts in isolation, to one in which texts are elevated "to the ontological status of things" and things elevated to the "dignity of texts" to be studied in relation to other such hybrid elements (Latour 1996b, p.376).

[57] In (Cooren 2004, p.388).

Latour lists some of the "essential traits of semiotics" used in the study of texts and kept in science and technology studies as follows:

> "First, the granting of humanity to an individual actor, or the granting of collectivity, or the granting of anonymity, of a zoomorphic appearance, of amorphousness, of materiality, requires paying the same semiotic price. The effects will be different, the genres will be different, but not the work of attributing, imputing, distributing action, competences, performances and relations. Second, actors are not conceived as fixed entities but as flows, as circulating objects, undergoing trials, and their stability, continuity, isotopies has to be obtained by other actions and other trials. Finally, from semiotics is kept the crucial practice to grant texts and discourses the ability to define also their context, their authors -in the text-, their readers -in fabula- and even their own demarcation and metalanguage. ... The slogans of the 60s and 70s "everything is a text", "there is only discourse", "narratives exist by themselves", "we have no access to anything but accounts" are kept in AT but saved from their ontological consequences. This salvation however does not come by falling back on the pre-deconstruction common-sense -"after all, there is a social context up there and a nature out there"- but by extending the semiotic turn to this famous nature and this famous context it had bracketed out in the first place."[58]

Latour demonstrates more specifically how texts and documents can provide a valuable resource in studies of technoscience in 'Pasteur on Lactic Acid Yeast: A Partial Semiotic Analysis' (Latour 1993). Latour makes the point that scientific texts and documents are as much part of scientific practices and the making of science as laboratories, instruments, controversies, disciplines, and institutions and as such should be considered as important actors in the building of actor networks (Latour 1993, 1996b):

> "Scientific texts, to be sure, have no privilege, but neither are they inferior to the many sources we have for understanding science. Indeed, when properly studied, they offer a convenient model to show how many mediations can be retrieved from the scientist's own practice. A scientific text is not only a more or less transparent medium to convey information to the author's scientific colleagues, nor is it only a document to help historians, psychologists, or sociologists retrieve the state of mind of its author or the context in which it has been written. As many decades of literary theory have helped us to see, texts are a little bit less and a good deal more than information and document. They build a world of their own that can be studied as such in relative and provisional isolation from the other aspects. They are localized events, with their own matter and

[58] In (Latour 1996b, pp.374-375)

> their own practice. ... In a fairy tale identical functions may be fulfilled by a prince, a dwarf, a magic rod, or a fox. This freedom in selecting actors and redistributing properties among them is crucial to understanding scientific practice ... . So, even though the ontology embedded in literary theory may be flawed, its ability to deal with nonhumans is without a par, and it allows us to go much further in the study of scientific work than do discourse analysis, rhetoric, or conversation analysis. Semiotics is the ethnomethodology of texts. Like ethnomethodology, it helps replace the analyst's prejudiced and limited vocabulary by the actor's activity at world making. To be sure, one cannot stop at the study of one text in isolation – but when adding other documents, other sources, other methods, the lessons learned from semiotics must be retained. There are mediators all the way down, and adding sources will only add more mediations, none of them being reducible to mere 'document' or 'information'."[59]

Latour, in his own words, "translates" semiotics as "path building, or order making, or creation of directions"(Latour 1996b, p.376). As a result, he suggests, the analyst "does not have to specify if it is language or objects one is analyzing" (Latour 1996b, p.376).

> "This move can be said either to elevate things to the dignity of texts or to elevate texts to the ontological status of things. What really matters is that it is an elevation instead of a reduction and that the new hybrid status gives to all entities both the action, variety and circulating existence recognized in the study of textual characters and also the reality, solidity, externality that was recognized in things 'out of' our representations. What is lost is the absolute distinction between representation and things – but such is exactly what AT wishes to redistribute through what I have called a counter-copernican revolution."[60]

Through such a conceptualisation, suggests Latour, pointing to the centrality of scientific texts and their production in analyses of scientific facts, knowledge, and discourses, texts and documents are transformed into actants in their own right and thus provide a way around the pitfalls of *interpretation* in analysis (Latour 1996b). Just like the other actants in a sociotechnical network, texts and documents should not be conceived "as fixed entities but as flows, as circulating objects, undergoing trials, and their stability, continuity, isotopies [have] to be obtained by other actions and other trials" (Latour 1996b, p.374). The analyst is, therefore, prevented "from telling the actors what to do" (Latour 1996b).

---

[59] In (Latour 1993, p.129)
[60] In (Latour 1996b, p.376)

This ability of texts to circulate and cross networks and their central involvement in moves from things to people and back, make them a useful methodological device in the study of situations of heterogeneous object building and the tracing of sociotechnical networks, as can be seen in the following explanation of circulating objects that trace sociotechnical networks and their relation to texts and semiotics given by Latour:

> "What happens when a circulating object leaves the boundary of a text? The traditional answer is that there is a yawning gap in between the text and the context. At the interface a dramatic trial is supposed to abruptly intervene through which the circulating object is assessed either by checking its referential fit or its social interest. Not for AT which does not believe in this distinction since it has extended meaning productions to all productions. For AT the gap is no more than a slight bump along the net; the yawn is an artefact caused by a previous divide between nature, society and discourse. For AT there is on the contrary a continuity, a multiplicity of plugs, between the circulating objects in the text, the claims outside the text in the "social", and what the actants themselves really do in "nature". The circulating object goes on circulating and goes on getting its isotopy from what other actors do to it. "Society" has the same net-like properties as the texts, and so has "nature". But it would be more accurate for AT to say that these three categories are arbitrary cutting points on a continuous tracing of action, and still more accurate to show how these categories are themselves part of the many trials, and events, and resources that are used along the paths to attribute "textuality" or "sociality" or "naturality" to this or that actor."[61]

It can be seen from the above that texts are an integral part of the paths around which circulating objects such as claims move and thus participate in the bringing together of the network being assembled. This is why they can be used effectively as an entry point from which to gain access to the network being assembled and other circulating objects tracing the actants involved and their relations.

Texts and documents in the research setting

In the specific setting of the Euroclear initiative to develop a cross-marketplace and cross-border securities settlement system being researched in this project, the project documentation was seen as providing a way of:

[61] In (Latour 1996b, p.381).

- Easily identifying and following the actants and the roles, links, and relationships among them that the new sociotechnical network being fashioned proposed
- Tracing the transformations and translations necessary to gradually bring the network of actants together and stabilise it

The project documentation was also seen as playing an important role as a communication and coordination device that crossed organisational and practice boundaries in this setting along the lines of the boundary crossing objects conceptualised by Star (Star and Griesemer 1989). As such, the documentation represented an unambiguous, public, and easy to follow trace of the developing associations that would eventually form this new sociotechnical network and the evolving relationships between concepts, discourse, action, and material inscriptions at the heart of this undertaking.

Ultimately, the texts and documents themselves are an integral part of sociotechnical network being built. They are more malleable versions of the arrangement proposed by the designers of the new settlement system assembled primarily out of concepts, assumptions, words, diagrams, numbers, theories and so on that progressively, through processes of consultation, negotiation, and implementation gain in materiality and physicality as they eventually get transcribed into ICTs. Following the associations found in them not only leads us to the actants involved, but also traces through time the changing controversies, translations and trials these actants are involved in.

From the inception of the Euroclear integration initiative there is an acknowledged need on the side of the designers of the new cross-marketplace settlement system that the project will depend as much on accommodating in its plans, through the development of the appropriate consultation processes, a number of external "stakeholders" and "principal third parties whose consent and/or co-operation will be needed" as on developing the new ICT settlement platform itself (Euroclear 2002).

The importance of documentation in this capacity and in this particular setting can be gauged from the explanations regarding the aims of consultation and other project-related documentation provided by Euroclear regarding the role and function of such documentation:

> "Communication with and consultation of all key stakeholders is a critical success factor for the implementation of the business model. ... The consultation papers are dynamic papers, typically one per programme, which are regularly updated with outcomes of feasibility analysis, market consultation input, etc. ... Working papers are interim or ad-hoc papers used for work in progress when required. They cover specific items that, once finalised, will be included in the consultation papers. In addition to direct communication with clients, consultation is also formally conducted through the Market Advisory Committees."[62]

It can be seen from the above that the role of the technical and other project-related documentation accompanying the development of the Euroclear single settlement platform is not simply a way of relaying information between the system designers and operators and potential users, but is central to the establishment of an intricate web of shared meanings, understandings, and interests. The documentation itself can be seen as a technology that brings together and links the participants in the overall endeavour of designing and developing such a marketplace mechanism.

As already stated, the approach taken is not concerned with the content of the documents to be studied, but their role as coordinating devices and in enabling the flow of circulating objects. In this light, the project documents can be seen as material objects into which many of the complex interrelations of those involved in the assembling are inscribed. By studying them and tracing how various issues and controversies evolve and how the entities being assembled move from words and concepts to things through the progression in time of the documents, it is possible to follow how people and things become linked together, how they shape and modify each other in the process, which human and non-human entities are involved, what problems arise in the proposed articulations, and how these are resolved in practice as the proposed

[62] In (Euroclear 2003d, pp.11-12)

arrangement moves from an abstract text-based form to an actual concrete material expression.

The texts and documents studied are treated as an integral part of the sociotechnical assembling being investigated; as the bare bones of the sociotechnical network being proposed to be fleshed-out in the process of the development of the new platform. They not only describe a certain proposed version of reality, but also participate in – and thus also trace – how this is transformed in the process of moving from words to things. They participate in this transformation process, contributing and generating inputs for the next stages in the design and development of the new system from the interactions they generate between designers and the entities to be enrolled that they come into contact with. The texts and documents, therefore, not only form a key part of the new emergent configuration of the assemblage under consideration but also represent a central repository of the numerous traces and inscriptions involved in the design and development of the new system as the new network is being shaped through the enrolment of the necessary actors and the gradual translation of their interests and goals until a stable network configuration is arrived at.

Through a process of public writing and re-writing, commenting, modification, and attempts to identify common ground and key sticking points and points of controversy among the proposed script and the actants to be enrolled and assembled, the documents and texts involved in the design and development of the new settlement system form a part of the initial branches of the heterogeneous network being built. Around this nascent arrangement, circulating objects that serve to co-ordinate and eventually bring together and bind the actants into the new network can start to flow. Only when all the actors involved are accommodated and can find their place in the new proposed order –at least on paper – will the new network, a cross-marketplace and cross-border securities settlement system, start to take shape and begin on its path to

eventually becoming a financial markets black box[63]. In the interim, there are a whole set of smaller black boxes that need to be closed and arranged together.

In addition to the ontological, epistemological, and methodological reasons for opting to concentrate on project-related documentation as a primary site of empirical investigation, one practical bonus of this approach in terms of the gathering of empirical material has been that, by design, this documentation is public and freely available[64]. It is, therefore, an easily accessible and readable trace of the higher-level enrolments, translations, and mobilisations involved in this process of sociotechnical network building being studied here. Furthermore, the documentation also provides a good opportunity for an outsider such as the researcher to become familiar with the debates and the shared vocabulary pertaining to the worlds of financial market clearing and settlement. This was of particular value in the later empirical work of following the actants and circulating references picked-up in the texts and documents into the more concrete aspects of the technology construction process through targeted interviews and informal conversations with settlement insiders [65].

Gathering and processing of empirical material

As outlined previously, the central empirical concern of the research has been to trace the assembling of the cross-marketplace securities settlement system

[63] It is obvious that before any expensive and difficult to reverse commitments to particular technologies or material structures are taken on, controversies have to have been overcome and contested issues resolved. By following processes of negotiation aiming at achieving such forms of consensus, insights as to how the resulting technology has been shaped and structured can be gained. In reverse, it should also be possible to 'read' from the technology and the logic it follows what the meanings and understandings shared by those who used it are.

[64] In the case of the UK settlement system for example, in accordance with the provisions of the agreements which CRESTCo, the settlement system operator has, entered into with system participants, "the introduction of material new functionality the use of which will not be optional and material changes to existing functionality will only be made after prior consultation". The consultation procedures adopted depend on the nature of the change, but involve one or more of the following: consultation by means of an article in the CREST newsletter, describing the issue and inviting responses by a particular date; consultation by means of the publication of a CREST 'Green Book' or 'White Book' that are distributed widely and are also usually referred to in, and usually distributed with the CREST newsletter; consultation through the establishment of working parties and liaison groups involving CREST participants who, in CRESTCo's view, fairly represent the principal types of participant likely to be affected by the issue concerned.

[65] They have helped as a kind of primer in the discursive orders and regulated discursive practices of securities market and settlement systems experts, helping the researcher to develop a better understanding of the rules, norms and conventions found in financial markets clearing and settlement practices.

being developed by Euroclear, identifying the entities involved, mapping their relations, examining the features of these relations, and following their progression and development through time.

The primary sources of empirical evidence used were project-related and consultative documentation, archival material, operations manuals, terms and conditions documents, newsletters, statutes, public policy and commercial reports, third-party responses to public consultation processes, interviews and ad hoc informal communications with people from both the settlement platform development side and market participants, minutes and reports from Market Advisory Committees (MACs), documentary and presentational material and notes taken from participation in workshops for market participants, and articles from the press and other media reports[66].

In addition there was a great deal of information and knowledge around broader issues relating to the strategic importance of clearing and settlement arrangements in the reconfiguration of financial markets acquired by the researcher from work on the Moving Markets research project of the Department of Information Systems at the London School of Economics and Political Science from September 2001 to December 2003. Through access to transcripts of interviews with over 65 senior strategy and business development executives at major clearing and settlement organisations from around the world, early versions of key reports (Giovannini Group 2003), transcripts of clearing and settlement conference proceedings, and attendance of seminars, meetings, and workshops with key clearing and settlement participants involved in the project, a great deal of first-hand experience of global developments in the clearing and settlement arrangements of financial markets was gained and through which many of the concerns that this research has aimed to address were first arrived at. In a sense, the Moving Markets project provided a kind of laboratory within which some of the assumptions and approaches opted for in this research project were elaborated and developed in

[66] While much of the consultation documentation produced by Euroclear was, by design, publicly available, a licensing agreement was signed with Euroclear for the use of that and other Euroclear material, both textual and visual, in this thesis. The wording of this agreement can be found in Appendix A.

preparation for it. This was particularly the case with regard to the importance assigned in the design of the project to the role of documentation, as it was seen, from the work of the Moving Markets project, that documentation – whether in the form of public policy reports and consultation documents, or public written submissions of key market participants to consultation processes, or commercial white papers, or even transcripts of key speeches by important individuals in the clearing and settlement sector – played an vital role in initiatives to reconfigure financial marketplace arrangements.

Based on all the above material, a narrative account, or chronicle, of the progression of the proposed sociotechnical arrangement from concept, to business plan, to consultation documentation, to service description, to development and implementation of the ICT platform was assembled, the highlights of which are presented in the next chapter.

Interest focused particularly on "which actant is stable, which one is reliable, which one induces deep modifications when added, and which one is insignificant" (Latour, Mauguin and Teil 1992, p.41).

Both the investigative effort and the narrative account developed from it focused on:

a) Understanding the techniques and strategies deployed by the designers and developers in order to bring about smooth and trouble free articulations between the human and non-human entities involved
b) Identifying points of friction at which controversies have arisen and deep modifications or detours from the original version of the arrangement made necessary.

Modifying the notion of social networks to one that encompasses the conception of the social adopted by actor-network science and technology studies that see it as a collective of human and non-human entities (Latour 1987, Akrich 1992, Latour, Mauguin and Teil 1992, Law 1992, Latour 1996c,

1999, 2005), a number of practical techniques where adopted and adapted from social network analysis for use in this investigation.

Visualisations of the arrangements proposed and articulations involved in the assembling of the integrated settlement system were obtained from such an extension of social network tracing techniques to the tracing of sociotechnical networks through the use of a social network visualisation software package developed by the University of Konstanz called Visone[67]. This way, visualisations of the proposed actants and the relations among them in different versions of the proposed network and at different phases of the project were obtained.

In practical terms, the documentation also provided a good starting point, or lead, from which the links between one actant and another involved in the assembling could be followed-up in other ways. So, for example, when one particular controversy relating to a specific proposed articulation was identified in the documentation, investigative attention could then focus on that through interviews, informal contacts and conversations, recourse to legal texts and statutes, and so on. Through such a "snowball" approach to network tracing, again adapted from the study of social networks (Hanneman 2001, p.8), relevant actants involved in some particularly interesting type of link or association could be identified and if necessary further evidence relevant to their involvement collected. In general, throughout the project, this controversy-centric approach was particularly useful as a guide to follow-up data collection beyond the kind of association mapping described above and that ranged from verbal and email clarifications of technical points or wider

[67] The origins of the Visone software lie in a joint project between the Algorithms and Data Structures Group in the Department of Computer and Information Science, and the Domestic Politics and Public Administration Group in the Department of Politics and Management of the University of Konstanz. The project has since evolved into a network of collaborations, with members in several different universities. It is a Java-based software tool intended for research in social network analysis and was designed to allow researchers to apply innovative as well as advanced established visual social network analysis methods and techniques with ease and in an intuitive way, whether dealing with large or small networks. Screen grabs of network visualisations developed in the context of this research project can be found in the Appendix (Fig. 14). For more details regarding the Visone network visualisation software tool, see: http://visone.info/about.php

issues, to identifying relevant media coverage, unstructured and informal conversations, and all the way to developing specific lines of questioning for the formal and extensive interviews undertaken.

This "snowball" approach to network tracing based on the following of further leads/links from actants already identified, approached, and studied, to the next layer, one step further away from the initial entry point was in practice a very useful approach throughout the evidence collecting process, helping to generate further empirical information and data, but in a way that still followed the logic of the network being traced. For example, from a conversation with those involved in the production of a document, other interlocutors from other parts of the organisation or from external stakeholders could be identified and traced. Information about which issues were problematic and which uncontroversial, what external influences might have come into play, how these were understood and then incorporated into the logic of the document assembled, what sources were used and so on was also gained in this way. Information about what approval processes specific claims in it went through, what kind of feedback was received, and how these related to the emergence of the next version of the document in question were also collected in this way and the traces thus encountered could then be followed to a next iteration of the network building process, whether this was in the form of an updated consultation document or a service description document that would then act as an input to the coders and other technical experts involved in the assembling of the ICT platform.

Summary

The aim of this chapter has been to illustrate how some of the practical choices made when designing the research project about how to study the setting being investigated relate back to key conceptual tenets of actor-network approaches to the study of technological objects.

The notion, proposed by Akrich (Akrich 1992), of technological objects as scripts that establish a "geography of delegation" by distributing roles to

human and non-human entities that together perform the proposed technological script, was revisited and linked to the ICT system being studied. The proposition by both Akrich and Latour (Akrich 1992, Akrich and Latour 1992, Latour 1992, 1993, 1996b) that in order to study technological objects as scripts a "semiotics of technology" needs to be undertaken that aims to decode, or "de-script", the syntaxes and grammars of the articulations that are brought together in a particular technological object, was then elaborated as were ways of doing this in practice proposed by Latour (Akrich and Latour 1992, Latour, Mauguin and Teil 1992, Latour 1993, 1996b). Particular attention was given in this discussion to the role project documentation, which was seen in the particular setting being researched as a particularly useful and important evidential resource, might play in such a "de-scripting". Finally, attention moves to the practicalities of collecting and processing the empirical material used in this investigation.

In the next chapter a narrative of the progression of the articulations involved in the assembling of a cross-marketplace and cross-border ICT-based securities settlement system is presented that follows the ' script' put forward by the designers from conceptualisation, through to texts and documents, to a durable material expression.

The research setting

The narrative presented in this section was assembled from the range of evidential sources used in the research project outlined in the previous section, primarily project-related documentation, notes and presentational material from practitioner workshops, formal and informal interviews, media coverage, press releases, and public policy documentation.

The objective has been to trace and present the most important articulation of actants involved in the assembling of the single settlement system being developed by Euroclear as this moves from the conceptual to the material.

Starting from the integration of the corporate entities involved, the narrative then moves to the business and project plan for the new platform, the key stages in these plans, and the methods and strategies proposed by the system designers in terms of taking these plans forward.

The account then switches to the first practical steps involved in the implementation of the Euroclear plan when an intense and exhaustive effort to record, sort, and compare the existing settlement arrangements of the systems to be integrated was undertaken that would then inform the harmonisation and/or standardisation necessary for a single system to come into being and a common platform to be built.

Attention then moves to the development of the first major concrete element of the new settlement system, the Single Settlement Engine (SSE), that by providing the existing separate settlement systems with a shared core functionality bridges a "structural hole" between the separate sociotechnical networks that are the existing individual securities marketplaces to be integrated, realising in the process substantial network effects and economies of scale that give the nascent entity a durability that will be vital if it is to succeed.

The importance of this durability becomes apparent when, as the new system gains a materiality, it starts to encounter more and more existing sociotechnical networks in the world around it with which it must interact and/or interface. Three such situations of varying degrees of complexity, importance, reach, and intractability are presented in the final part of the account.

The Euroclear Single Platform: from concept to material reality

Corporate Integration

The starting point of the initiative to integrate the five separate securities settlement systems being studied here can be traced back to 2000, when, having fully separated from JP Morgan at the end of 2000 and established Euroclear Bank to run its settlement platform, Euroclear, the Brussels-based central securities depository for Eurobonds and other international securities, embarked on a strategy of mergers with a number of CSDs in Europe[68]. This was seen by Euroclear as a way of positioning itself to take advantage of the future business opportunities expected to flow from moves to establish a single market for financial services in the EU, the growing adoption of sectoral rather than geographical investment strategies, and the growing demand for derivatives linking together different financial instruments and asset classes (Euroclear 2005b, Interview C 2006).

At the centre of this strategy have been a series of mergers starting with Sicovam SA, the French CSD and settlement system operator in January 2001,

[68] Euroclear started as a DvP settlement services set up by the Brussels office of Morgan Guaranty Trust Company of New York (now JP Morgan) for the issuance and trading of dollar denominated Eurobonds. It was based in Brussels and operated under Belgian jurisdiction. The service went live on 1 December 1968 and introduced a number of technological innovations, for the time, such as pre-settlement matching of instructions, fungibility, and punch-card electronic processing equipment (Shearlock and Ellington 1994). In 1972 a separate corporate entity, Euroclear Clearance System Ltd (ECS), was established to take over the settlement system. In this way ownership of the company was passed to the market participants that used it, with the operation of the system contracted by the company back to Morgan Guaranty in Brussels (Shearlock and Ellington 1994, Euroclear 1999). Euroclear is one of two entities referred to as International CSDs, or ICSDs. The other was Luxemburg-based Cedel that has now been absorbed into Clearstream, whch is part of the Deutche Borse group. More details regarding the history of Euroclear are available in Appendix F.

Necigef, the Dutch CSD in February 2002, and CRESTCo, the UK CSD and settlement system operator in September 2002[69].

On 1 January 2005, following these mergers, the corporate structure of the Euroclear group was reorganised, with Euroclear Bank, initially the parent company of the CSDs of the group, becoming a sister company of these CSDs, and a new non-bank holding company, Euroclear SA/NV, becoming the parent company of both the domestic CSDs and Euroclear Bank. It is this company that is developing and will own the Single Platform.

The new corporate structure was seen as necessary in order to provide reassurances to the market, to regulators, and competition authorities that "a proper separation of CSD and ICSD activities" was in place and transparency regarding questions of cross-subsidisation of the group's ICSD through the activities of the CSDs (Euroclear 2005b). The group's corporate structure at the time is summarised in the following diagram.

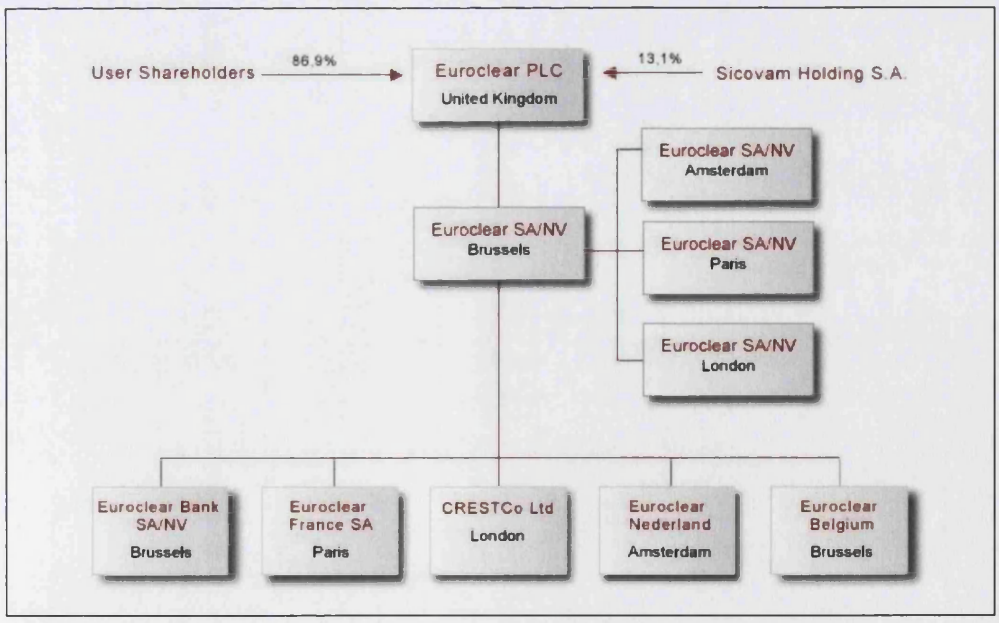

Figure 1: Post-merger Euroclear group corporate structure (source: Euroclear)

[69] CIK, the Belgian CSD was acquired fully from Euronext, the company that owns the Paris, Brussels, Amsterdam, and Lisbon stock exchanges, on 1 January 2006 (Euroclear 2005).

Planning a cross-border marketplace

The "Delivering a domestic market for Europe" document

The objective of the Euroclear integration initiative can be summed-up by the phrase: "Delivering a domestic market for Europe". This was the phrase used by Euroclear as the title for the first public document on its plans for developing a cross-border settlement system for securities that was published in July 2002 as part of an explanation of the rationale behind the proposed merger between Euroclear – already comprising of Euroclear Bank, Sicovam, and Necigef – and CRESTCo, the company that owned and operated CREST, the UK securities settlement platform[70]. The opening paragraph of the main body of the document states:

> "We intend to cut away the current costs and complexity of cross-border settlement by removing the borders. We intend to create a single domestic settlement space covering the five countries in the New Group – Belgium, France, Ireland, the Netherlands, and the United Kingdom."[71]

This would be done through the development of a common securities settlement system for all the marketplaces served by the newly constituted group that, it was anticipated, would reduce cross-border transaction costs "by up to 90%" bringing them down to the "low levels prevailing in domestic markets", giving users the opportunity to "access directly a single operational securities account, on a single platform, spanning domestic securities markets" (Euroclear 2007).

[70] Details about the dematerialisation of securities in the UK, the establishment of CRESTCo, the development of CREST, and its key features and ICTs can be found in Appendix E.
[71] In (Euroclear 2002, p.5)

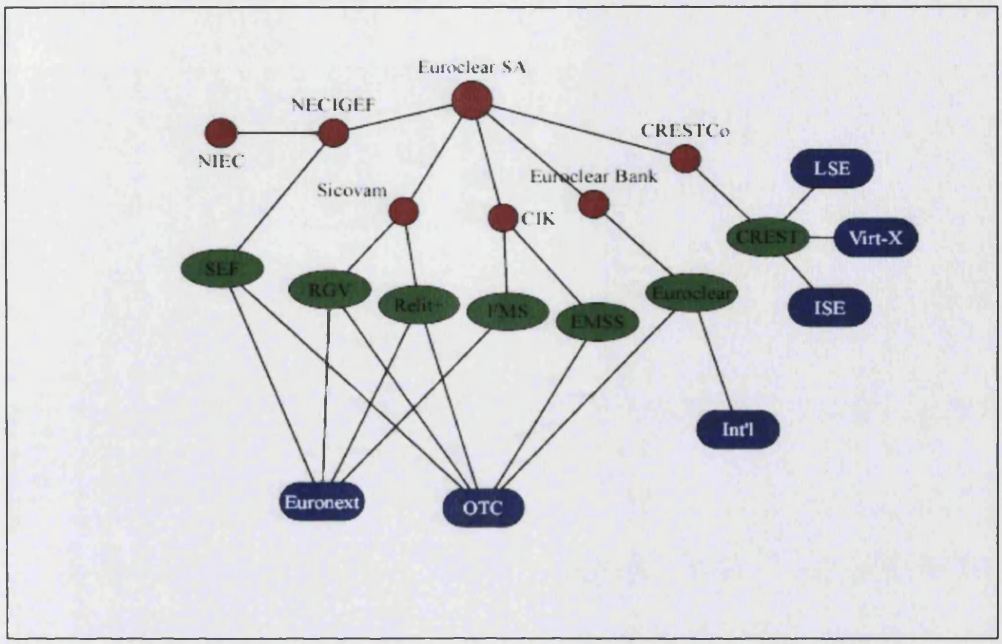

Figure 2: Visual representation using the Visone software of the relationships between corporate entities (red circles), settlement platforms (green ovals), and marketplaces (blue lozenges) following the mergers between Euroclear and the CSDs

In order to achieve these aims two central high-level objectives were identified:

- Consolidation of the services provided by the group on to a single ICT-based settlement platform, the Euroclear Single Platform
- Harmonisation of the various practices relating to settlement, custody, payments, reference data, and tax found in the local markets to be integrated and inscribed into the systems operated by the individual group CSDs

The implementation of the new model was to be in stages, with the final goal being to offer "a single access point to both domestic and full services" and allow "book-entry settlement of all transactions between Euroclear group customers on a single platform" (CRESTCo 2004).

The starting point of the integration plan was that those services which were available at the time in each of the group's CSDs and which were essential to meet the basic needs of anyone who holds and trades securities in the home markets covered by the group should continue.

The first phase of "Delivering a Domestic Market for Europe" envisaged the development of the Single Settlement Engine (SSE) that would replace the existing core settlement processors of the constituent CSDs while leaving the other components of their legacy systems largely in place[72]. Once completed, the SSE would be in a position to deliver settlement of cross-border transactions across the various group entities "on an internal book-entry basis"[73].

During the second phase, a complete consolidation of all group CSD platforms and systems was envisaged, providing access to the new shared platform over a common interface for all users of the consolidated Euroclear group, irrespective of jurisdiction (CRESTCo 2004). Upon completion of migration to this new Single Platform, customers would have the possibility of "accessing all group securities through one securities account, with one interface, one payment relationship", but "with a choice of service levels and tariffs" (Euroclear 2002). System participants would still be able to choose either direct legal ownership of their holdings through one of the existing local CSDs or to hold their securities in a "fungible pool governed by Belgian law" through Euroclear Bank as part of the so called "full service". They would also be able to choose between different payment arrangements, from having a direct account with a central bank in those jurisdictions that permit it, to using a Settlement Bank in those that do not (e.g. UK), all the way to using commercial bank money in a wide range of currencies if they opt for the Euroclear Bank service.

The high-level requirements set out in the document regarding the integrated ICT platform were that it should:

[72] The functional distinction between the core settlement processor of an ICT-based securities settlement platform and the other elements that make up such a platform are illustrated in the section in Appendix E that describes the architecture of the CREST platform in the UK.
[73] What is meant by 'internal book-entry basis' is that users will be able to access any securities they hold with any CSD in Euroclear through a single umbrella account with sub accounts, allowing transfers across these accounts to be treated as internal transfers, eliminating any external costs and transforming them into simple book-entry transfers as would be the case with a domestic trade (Euroclear 2002)

- Deliver consolidation and remove duplication of investment through a realistic and phased migration path
- Operate effectively within the context of complex and heterogeneous local market practices in Europe
- Enable all customers to enjoy at an early stage a significant part of the benefits of consolidation at the same time as obtaining full value from their current settlement interfaces and back office systems
- Be readily extendable to further CSD systems not within the Euroclear group at the time

The first phase of the project

In terms of the actual implementation steps to be made in the first phase of the integration project and in developing the SSE, the "Delivering a domestic market for Europe" document highlighted the following:

- Identification of core functions of the existing platforms[74]
- Incorporation into SSE design
- Mapping of interfaces with various systems (e.g. delivery of different forms of central bank and commercial bank money, complex local deadlines, accommodation of specific local settlement practices)
- Implications of these on the use of existing software
- Focus on the design of the book-entry transfer processing function

The Single Settlement Engine (SSE)

The SSE was conceived as providing the "core settlement and payment functionality that will interact with each local customer-facing system" (i.e. CREST in the UK or RGV in France) (Euroclear 2002).

[74] Non-core functions and those only found in particular CSDs were to remain with existing CSDs during the first phase (e.g. Deliveries by Value (CREST), triparty repo (Euroclear), automatic substitution in repo transactions with the Banque de France in RGV). Throughout this phase users would be able to access the SSE functions (as well as the functions of each ICSD system) through their interface with their existing CSD using the messaging and reporting functions of that CSD and not interacting directly with the SSE itself.

The SSE would – in effect – act as an interface, or translation device, between the separate local market frames inscribed in the settlement platforms of the constituent CSDs and dealing with "the complexity of the various systems with which it interfaces, in order to deliver the different forms of central bank money and commercial bank money, as well as facilitating a complex set of local deadlines and settlement practices" (Euroclear 2002).

Market participants would, during this phase of the integration project, interact with the SSE only through their existing interfaces with the local CSDs and their legacy platforms using the messaging and reporting functions of those CSDs.

Once in place the SSE would:

- Enable the transformation of cross-border settlement between two Euroclear group counterparties into internal book-entry settlement;
- Offer cross-National Central Bank money settlement in Euro;
- Offer cross-quality settlement between a counterparty wishing to settle in central bank money and a counterparty wishing to settle in commercial bank money.

The main benefits of an integration approach based around the SSE proposal were judged as being:

- Speed of delivery
- Lower costs imposed on the market
- Less risks of failure

The reasons give for this assessment were that:

- The scope of the SSE was closely defined and therefore more easily deliverable

- It minimised the impact on customers' back offices and preserved the value of their investment in their CSD interfaces for a longer period
- It focuses on the short-term delivery of a solution for core settlement functions where there is already a relatively high degree of harmonisation in market and processing practices
- It recognise that, initially, country-specific and other differences in market practices in each of the group's domestic markets might need to continue for some time.

The second phase of the project

In the "Delivering a domestic market for Europe" plan, the SSE was also seen as "the base from which the group can deliver ... additional services ... to all customers of the group and across all their securities" (Euroclear 2002).

Beyond the level of ICT platform consolidation, the document acknowledges that it is important to "press strongly for continued development of harmonised and standardised market practices" because "without significant change in market practice and in the legal, regulatory and tax structures in Europe, the goal of a fully integrated European capital market will not be achievable" (Euroclear 2002).

With the SSE in place, the main priorities would then become:

- The integration and expansion of other subsystems (e.g. corporate actions, issuer services) around the SSE, with priority given according to their value to users, improvements delivered in terms of the performance and functionality of the integrated system, ease of maintenance, leveraging of existing software and know-how, development time, costs and so on.
- To use the insights and market weight gained from the SSE implementation to press for changes in market practices and legal, regulatory, and tax structures

- To harmonise customer interfaces in line with the latest developments in messaging standards (e.g. ISO15022, XML)

The business case

The Euroclear document draws from the work of a number of reports and studies from expert groups such as the Centre for European Policy Studies (Lannoo and Levin 2001) and the Giovannini Group (Giovannini Group 2001) when presenting its argumentation regarding the business case for its "Delivering a domestic market for Europe" plan[75].

While not in a position to provide an exact and detailed costing of the integration project, the "Delivering a domestic market for Europe" document did set out, in a qualitative way, the various cost savings envisaged from this initiative and provided an argumentation regarding how they might be achieved in practice.

The main areas of savings given were:

- Tariff savings resulting from the removal of the need for cross-border settlement for inter-group securities transactions and their transformation, in effect, into low cost domestic settlement transactions
- Back office savings for market participants resulting from the standardisation of procedures across the domestic markets served by the Euroclear group and the development of a standard customer interface[76]
- Central infrastructure savings resulting from the consolidation of market infrastructures and the avoidance of the need for duplicate investment[77]

---

[75] As was the case with the design and development of CREST, outputs from international expert groups and industry organisations have played an important role in framing the debates relating to the establishment of cross-border financial markets.

[76] A large part of these costs arises from having to maintain interfaces to several different CSD platforms whose technical specifications, messaging arrangements and methods of operating are mutually incompatible. This means that that the investment that a market participant makes in interfacing with one CSD can rarely be re-used when interfacing with another. In many cases the prospective cost of interfacing to another CSD in a market where that participant's activity might be small altogether outweighs the benefits of doing so.

- Lower costs relating to the reduction of a number of risks and the more efficient use of working capital (e.g. reductions in the credit risk resulting from timing differences between the settlement process in a local market and the delivery of the securities to the home CSD, reductions in the operational risk involved in the existing multiple and often complex and unwieldy interfaces between discrete domestic marketplaces, reduction in the financing costs inherent in cross-border settlement activities due to the fragmentation of collateral in discrete domestic settlement systems).

Ownership and governance

Unlike the case of CRESTCo where the corporate ownership and governance structure of the settlement system operator was as much a part of the design of the system as the ICT platform, the post-consolidation corporate ownership and government structure of Euroclear was more a reflection of the ad hoc assembling of the constituent elements of the entity brought together through a series of mergers and acquisitions[78].

In the first instance the shareholdings in the combined concern of the various constituent entities reflected the relative 'weight' in the combined system of each individual CSD. These would then be distributed to the members/users of the individual constituent CSDs according to the arrangements and shareholdings prevalent at the individual CSDs. While there are no formal shareholder re-balancing mechanism proposed for the combined entity, as was the case with, for example, CRESTCo where shareholdings would be periodically altered to reflect changing levels of usage of the system by a particular user or user group, in the "Delivering a domestic market for Europe" document there is only a commitment from Euroclear "over time to enabling

[77] For example, two data centres (live and standby) rather than eight, fewer inter-CSD links and links with CSDs outside the group, increased purchasing power across the Group, rationalisation of support functions and back-up arrangements, reduced number of upgrades when systems reach their end of their planned usage.

[78] Details of the development and approval of CREST can be found in Appendix E.

shareholders to increase their shareholdings where that is justified by their usage and enabling users who are not shareholders to acquire shares".[79]

There is also no formal mechanism proposed for the distribution of profits in a way that balances returns to shareholders with rebates and fee reductions to the market as a whole and investment in the settlement platform. The document simply suggests a distribution of dividends "at least equal to 60% of the first 15% of return on equity", with the Board of Euroclear deciding on an annual basis "the distribution of the financial surplus" in terms of retained earnings, fee rebates for customers, and dividends to shareholders.

The Board itself would "reflect the geographical and sectoral spread of the new Group's users" and would also include two independent directors "who are not associated with any user firm".

Market Advisory Committees (MACs)

One innovation proposed in the document in relation to the governance of the emerging cross-border system is that of the Market Advisory Committees, seen by Euroclear as a way of being "responsive to the needs and interests of all its customers, large and small, in all the markets that it serves". While already part of the French settlement system, the Market Advisory Committee structure would now be introduced to the other constituent domestic markets and strengthened by being given a formal status with defined rights and responsibilities.

The Market Advisory Committees (MACs) were seen by Euroclear as "a primary source of feedback and interaction between the [Euroclear] Group and the user community of the markets for which the Group acts as CSD on all significant matters affecting their respective markets". Although the MACs would "not replace the Boards of Euroclear Plc or Euroclear Bank as the decision making bodies of these companies, their influence is expected to be all

[79] There is no requirement in the articles of association of Euroclear for a holder of Euroclear shares to be a user of the Euroclear system or any system operated by any of its subsidiaries (unlike the comparable provision in the CRESTCo Articles). The Euroclear articles of association provide that Euroclear directors have an absolute discretion to refuse to register transfers of Euroclear Ordinary Shares.

the more significant as they will have the right to address directly the Chairman and the Board if they consider that it is necessary to do so".

Membership of the Market Advisory Committees would be "widely drawn, to include the principal sectors relevant to each individual market". This would include representation from the retail sector, institutional brokers, custodians, market makers, registrars/receiving agents and the gilts market.

Euroclear Settlement of Euronext-zone Securities (ESES)

An important intermediate step towards the creation of a single cross-border transaction-processing platform for Euroclear, but one not included in the initial "Delivering a domestic market for Europe" plan[80], was to offer a harmonised settlement platform for the straight-through processing of trades from the Euronext[81] single order book at the centre of the consolidation of the Paris, Brussels, and Amsterdam stock exchanges.

The Euroclear Settlement of Euronext-zone Securities (ESES) system would provide the Euronext-zone market CSDs (Euroclear Belgium, Euroclear France and Euroclear Nederland) with an integrated settlement system and harmonised custody service for both stock exchange and over-the-counter transactions. Euronext market participants would thus have "a single access point of their choice to settle trades conducted on any of the Amsterdam, Brussels and Paris segments of the Euronext exchange" (Euroclear 2004b)

The ESES system, due to be launched gradually at the end of 2007 and in the first half of 2008, would replace the existing settlement platforms in France, the Netherlands, and Belgium with a modified version of the Euroclear France Relit à Grande Vitesse (RGV) platform but that for settlement processing would now have the SSE at its heart. By the end of the introduction of the common ESES system the number of platforms within the Euroclear group would be reduced from five to three, making the full integration of the

[80] The decision to embark on the ESES project was taken by the Euroclear Board in July 2004, "following intensive consultation with, and clear endorsement from, the Group's markets". The Euroclear board approved full implementation on 30 June 2005.

[81] The single corporate entity formed out of the merger of the Paris, Brussels, Amsterdam, and Lisbon stock exchanges and London futures exchange LIFFE.

individual Euroclear settlement systems and transition to the Single Platform less onerous. The ESES system would also include a number of new components developed for the Common Communication Interface (CCI) and the Single Platform.

The benefits of the ESES project according to Euroclear would be:

- Support for the consolidation of the Euronext stock exchanges post-trade environment;
- Direct access to the different CSDs in the Euronext zone;
- An important materially durable step in the direction of the harmonisation of market structures and practices across three markets;
- Project risk reduction for the Single Platform through the development of an interim solution prior to its final implementation.

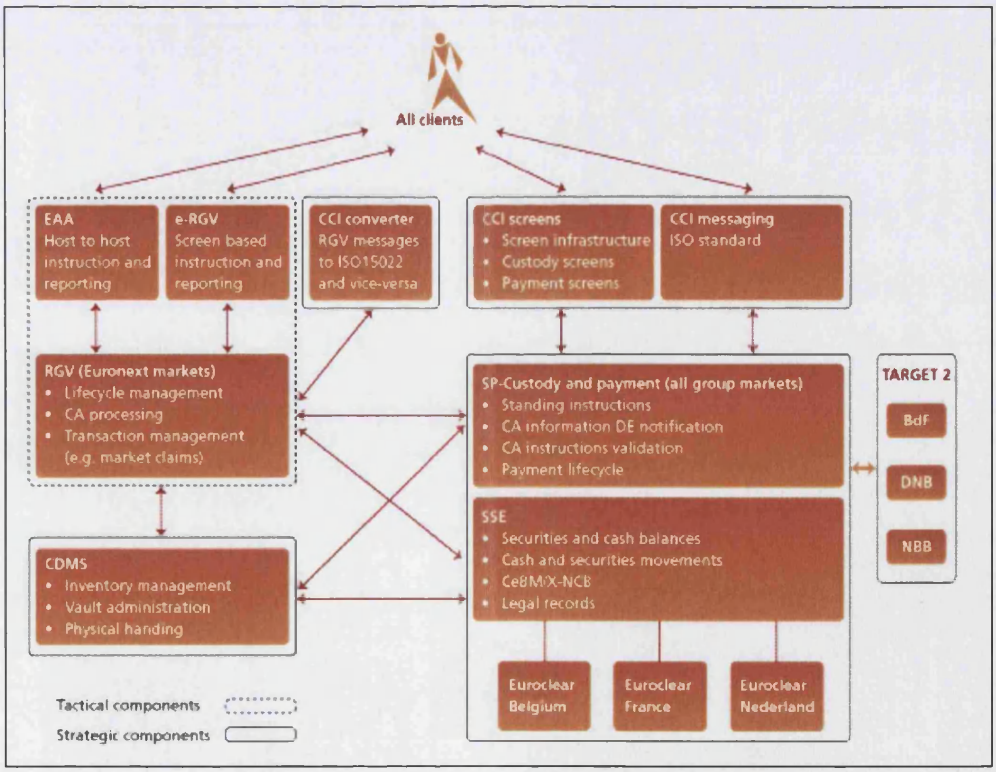

Figure 3: The architecture and components of the ESES system (source: Euroclear)

According to the "ESES Blueprint - Edition 4 Update Paper" published by Euroclear on 24 August 2005, there would also be interim benefits in terms of

communications, with the long-term Common Communication Interface (CCI) being partially implemented in the context of ESES as a complement to the existing Euroclear France communication channels.

Users of the ESES platform would be able to use a combination of interfaces, according to their country of origin and the service offering, as follows:

- Current users of Euroclear France communication channels would be able to continue using their current input and reporting tools (i.e. screen access via e-RGV and/or host-to-host communication via Euroclear Access Application (EAA)), while also being able to subscribe, if they prefer, to the new CCI
- New users would have the possibility of communicating with the ESES platform using CCI STP and in compliance with ISO messaging standards for input and reporting relating to the main set of RGV messages, using a converter that would provide ISO messages to RGV
- Screen functions would be available through CCI and through e-RGV, for all participants.

In the latest release schedule for ESES (Autumn 2006), Euroclear anticipated the gradual introduction of the ESES platform to Euroclear France users in November 2007, with the removal of the Relit+ deferred settlement system and the introduction of the complete ESES functionality by February 2008.

By May 2008 Euroclear expected the migration of Euroclear Nederland and Euroclear Belgium users to the ESES platform to have taken place.

ESES would also be in a position to connect to the TARGET2 pan-European payments system developed by the European Central Bank as soon as the Euronext countries migrated to TARGET2 before or around this time, but if further delays to the TARGET2 project were announced before June 2007, Euroclear would have the option to migrate all individual markets to the previous TARGET payment system.

The Common Communications Interface

The Common Communications Interface (CCI) referred to in the ESES plan above was Euroclear's proposal, included in the initial "Delivering a domestic market for Europe" plan, for moving clients across all the group's CSDs to a single interface through which to access all Euroclear services that will eventually be incorporated into the Single Platform. Clients will thus be able to "consolidate their communication interface and streamline the message formats [used] across a number of European markets as well as reduce paper communications, discontinue telex communication and improve straight through processing (STP)" (Euroclear 2004a, p.6).

The main components to be brought together in the CCI would be:

- Networks (technologies, service providers, accreditation)
- Message delivery channels (screen input, file transfer, applications)
- Access control to the settlement system (security, encryption, authentication)
- Report management (system report requests, subscriptions, and distribution)
- Data formats (standards, ISO)

The expectation was that the CCI would be fully implemented by late 2009, but individual CSDs would migrate to this platform in "multiple sub-phases" (Euroclear 2006a).

Early Harmonisation and the Single Gateway

The Early Harmonisation element of the overall transition to the Single Platform, like ESES, was not part of the "Delivering a Domestic Market for Europe" plan. It was proposed to the Euroclear Board in December 2004 as "a preliminary step to the group's consolidation efforts" through which elements in the custody, settlement and securities financing service offerings on the legacy CREST and Euroclear Bank platforms would be "selectively adapted in order to reap early harmonisation benefits by unlocking back-office savings earlier than would otherwise be possible" (Euroclear 2003b).

The Early Harmonisation addition to the Euroclear plan was intended to build on the harmonisation made possible by the development of the ESES platform for the Euronext markets and extend it to the CREST and Euroclear Bank markets by introducing changes earlier than envisaged in relation to the original Single Platform development plan.

The early harmonisation programme would include changes to ISO messages used by the CREST, Euroclear Bank and ESES systems, with the intention being to broaden the ISO standard coverage of the systems and align the existing coverage with the eventual Single Platform. The thinking was that by taking up the option of conducting more of their business via ISO standard messaging, Euroclear customers would reduce the impact of the eventual migration to the Common Communication Interface (CCI). No existing proprietary messages would be withdrawn as a result of this initiative as these will only be withdrawn progressively with the implementation of the Single Platform.

The Single Gateway is part of this intermediate plan. It aims to rationalise the numerous communications channels (screen-based, STP) that the clients of Euroclear currently employ to communicate with the different CSDs in the group. Each of these existing communications channels use proprietary gateways and security protocols.

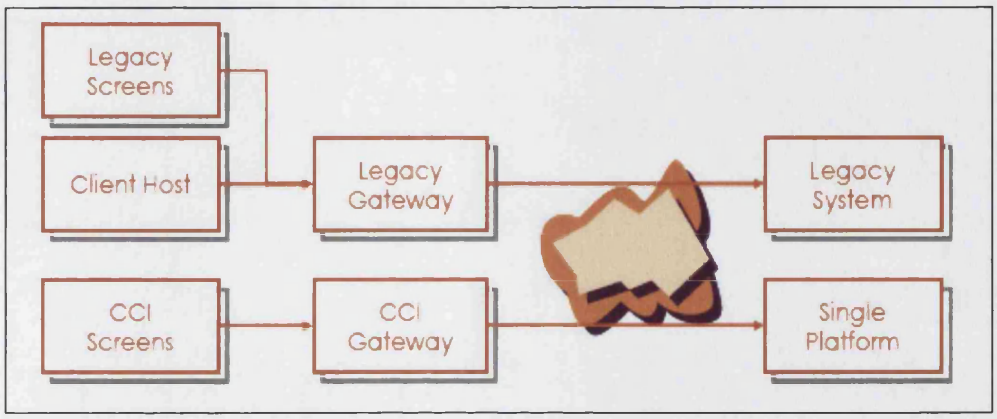

Figure 4: Existing channels for communications between users and settlement platforms in the Euroclear group and those proposed in the CCI plan (source: Euroclear)

The implementation of ESES will consolidate the systems of Euroclear France, Euroclear Belgium and Euroclear Nederland into a single system and while this would reduce the number of gateways required for a client operating in the Euronext markets, it would require additional gateway and network components with the introduction of the CCI and the Single Platform.

The Single Gateway initiative aimed to provide clients with the option of consolidating their gateways and networks in advance of the full implementation of the Single Platform, allowing a number of these communications channels to use just a single gateway and network connection. The Single Gateway would allow both screen-based and straight-through processing traffic, both in proprietary and harmonised ISO formats, to connect to existing legacy and evolving Single Platform systems.

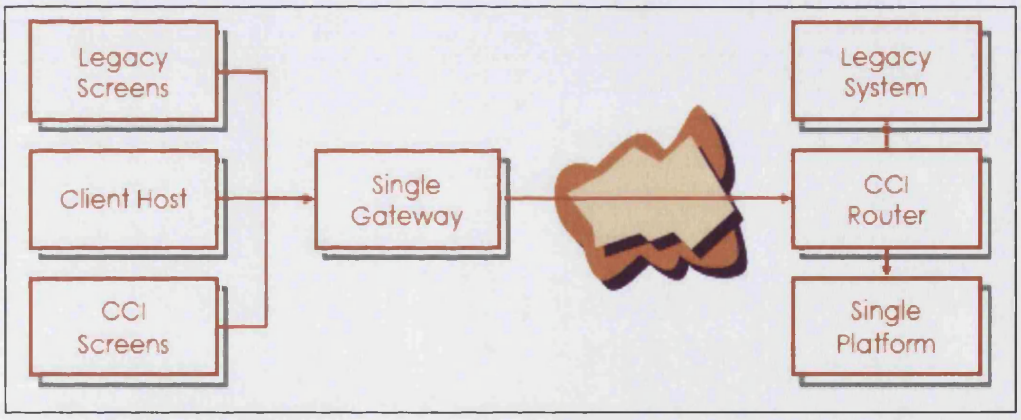

Figure 5: Communications arrangements proposed in the Single Gateway initiative (source: Euroclear)

Without the Single Gateway, even a client operating in a single domestic Euroclear market would see an increase in running costs for gateways and networks during the migration to the Single Platform as the addition of the CCI and Single Platform components would require an additional gateway and, possibly, an additional network connection.

The Single Platform

Following the launch of the SSE and the ESES platform, all the remaining functions from the Euroclear group CSD legacy systems would eventually be integrated on to the Single Platform.

A representation of how the various layers of the project come together in the final cross-border settlement platform is provided below

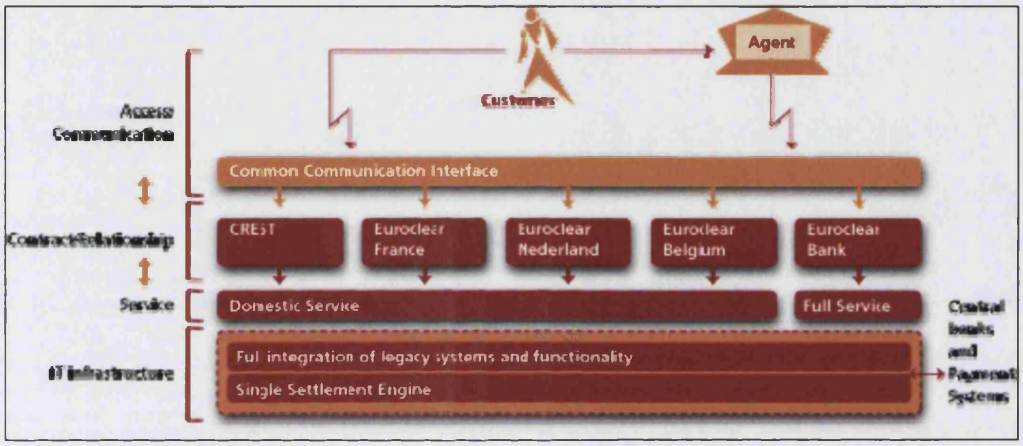

Figure 6: Assembling the Single Platform (source: Euroclear)

It is anticipated that the platform will be delivered in the second half of 2009, with the three remaining CSD platforms after the introduction of the ESES system migrating at intervals of roughly three months.

Other ancillary developments would be delivered shortly after. This would cover functionalities that only exist in one market and thus do not require harmonisation but only a simple migration to the new platform.

The following diagram illustrates the proposed sequence of the various systems consolidation stages involved in the Euroclear market integration project.

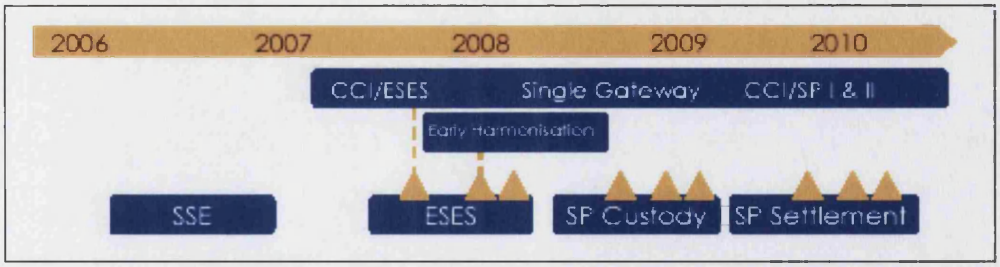

Figure 7: The Single Platform timeline (source: Euroclear)

Harmonisation, standardisation, and comparability

From the conceptual level all the way down to the level of the smallest components of the settlement platforms, one of the first practical tasks of those involved in the development of the Euroclear cross-border securities settlement system had been to establish a comparability between the five different frames inscribed into the different legacy settlement platforms they are attempting to integrate[82].

What can be seen in the documents published by Euroclear on the harmonisation necessary for the SSE and eventually the Single Platform to take shape (Euroclear 2003c, 2004c, 2004d) is that the original introduction of ICTs to securities settlement in a local context had contributed to the establishment of an initial degree of comparability that made possible the conception of a plan for the cross-border integration of five different settlement systems.

Another important contributing factor to the establishment of this initial comparability needed for such an integrated settlement system to be conceived and the actions necessary to bring it about rendered more visible and explicit was the gradual assembling of a formalised body of knowledge relating to the clearing and settlement arrangements of financial markets. As can be seen in the timeline presented in the figure that follows, from soon after the 1987 market crash to about 2003, a whole raft of reports from international financial industry organisations such as the Bank for International Settlements

[82] Comparability here is used in the sense of the Latin roots of the word "compare" which is *comparare*, "to make equal with, liken", from com- "with" + parare "to make equal". This implies that two things that were different to start off with are in some way operated on in order to make them in some way equivalent, but without their original characteristics being lost.

(Committee on Payment and Settlement Systems 1992, 1995, 2001, Committee on Payment and Settlement Systems and Technical Committee of the International Organization of Securities Commissions 2001), IOSCO (Committee on Payment and Settlement Systems and Technical Committee of the International Organization of Securities Commissions 2001), and the Group of 30 (Group of Thirty 1988, 1990b, 1990a, 2003) set out to codify securities settlement system arrangements and put forward best practice recommendations regarding their design and operation [83].

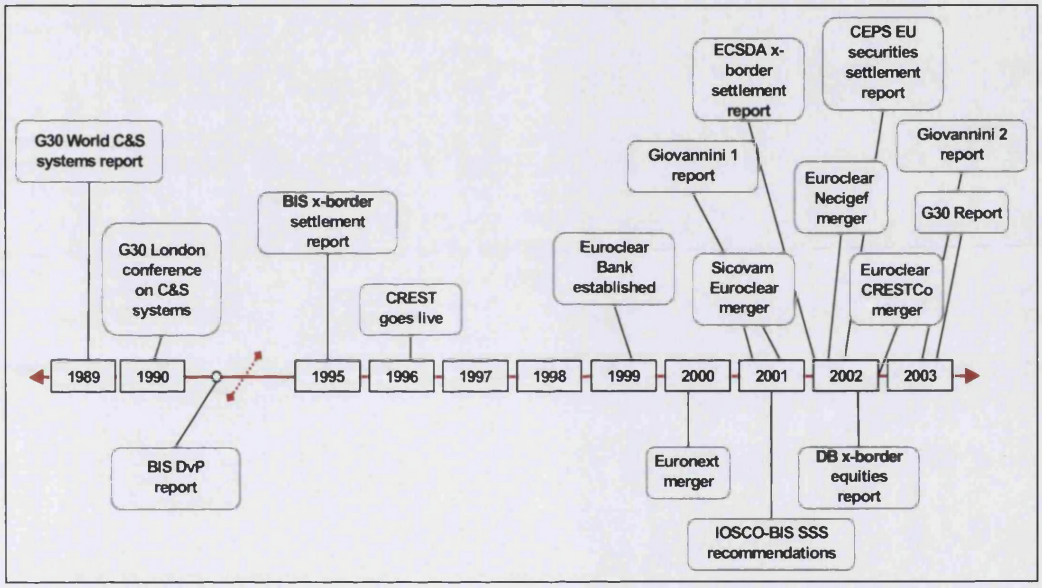

Figure 8: Key reports contributing to the emergence of a formalised body of knowledge around the clearing and settlement arrangements of financial markets and their relationship in time to the evolution of the Euroclear integration initiative.

Through their descriptions, comparisons, categorisations, and classifications of the systems, functions, processes, and risks involved in the settlement arrangements of the marketplaces studied, these reports taken together contributed significantly to the framing and conceptualising of financial market settlement, both domestic and across borders as the following comment by a

[83] Attempts were also made to quantify, compare, and attribute the costs of clearing and settlement, especially at the EU level where the fragmentation of the capital markets was seen as an important impediment to the development of a single market and a source of economic inefficiency (Lannoo and Levin 2001). A wide-ranging controversy regarding how such costs could or should be measured ensued out of these initiatives (Deutsche Borse Group and Clearstream International 2002).

now retired senior figure responsible for market infrastructures at the Bank of England shows:

> "The day that the G30 [1989] report was launched, we actually had a conference for publicity, like a press conference, in the Mansion House, which was attended by Eddy George, who was the deputy governor of the Bank of England at the time, by John Reed who was the chairman of Citicorp ... at the time, Andrew Hugh-Smith chairman of the [London] Stock Exchange was there, Gerry Corrigan was there, and I thought, I remember saying: whenever in the history of financial markets, have you had big hitters like that at the same table talking about clearing and settlement? Never! This was the beginning of the sea change in recognition of its importance to risk management, the efficiency of markets and so on. So, there was [now] a degree of [industry-wide] coordination, if you like."[84]

An industry-wide shared understanding of the issues started to take shape and best practice and standards suggestions included in them increasingly taken into account in the design of ICT-based settlement platforms[85]. Differences and similarities between systems started to become much more visible and explicit and an awareness of the strategic importance of such systems to both commercial and public policy objectives started to emerge. These new understandings and conceptualisations inevitably informed the integration strategy of Euroclear going into the corporate mergers out of which the new group has emerged, but also in terms of the planning and development work that has gone into the building of the Single Platform.

ICTs have also participated in this framing of securities settlement arrangements and the comparability and calculability this has engendered. Comparing the legacy settlement platforms that will eventually be replaced by the Single Platform, one can see that, despite idiosyncrasies in implementation, and differences in settlement practices and legal frameworks they inevitably reflect, their architectures at the most basic level share some important core similarities. A senior member of the Euroclear division in charge of the Single Platform project commented on this point as follows:

---

[84] In (Interview D 2006)

[85] With the development and approval of CREST, for example, the UK, which up to then had one of the few remaining distributed rather than centralised settlement systems, also adopted a CSD model based around a central register of securities and book-entry transfer between holders.

> "If you think about it, if you've got a system, you've got clients at the far end, over there. People, computers, people using screens or what have you; host-to-host communications. You've then got – typically – a communications message that comes-in over the network. Typically you've got a communications layer and then you've got a number of back office systems. For the securities market you [can] pretty much break that down into [those] four elements."

All of the legacy systems to be integrated have some kind of gateway on the premises of a user through which both individuals inputting instructions or other computer applications connected to the gateway can send and receive instructions in the form of electronic messages to the settlement platform via a secure data telecommunications network.

On the side of the platform there will be an application that will also connect to the same secure telecommunications networks to receive and send messages to and from the users' gateways and process the instructions received, either storing them or sending them on to a settlement processor, again using electronic messages[86].

The settlement processor then checks a number of account databases to make sure that the necessary resources (e.g. securities, cash) for the proposed transaction to take place are available. Once this has been ascertained, the transaction message is placed into a sequence or queue to be processed by an algorithm running on the processor's computer system. The algorithm works through the sequence of transaction instructions, deleting the securities data being sold from the securities account database of the seller and entering them into the securities account database of the buyer and doing the same in the opposite direction with regards to the payment and cash accounts of the transacting parties. Finally, some kind of record is generated and stored and a specific reporting procedure is carried out back to the transacting parties.

---

[86] In the CREST system for example the Applications Host first of all sought to match each incoming transaction instruction from one transacting party with its other half from the counterparty and once this was done, depending on the date specified, would either send the matched transaction to the Settlement Processor or store it for later processing.

The comparability among ICT-based securities settlement platforms is not only at a procedural level. The ICT building blocks of the various systems are also similar across different legacy market frames. Key such components include:

- Electronic messages
- Parsers
- Encryption and authentication technologies
- Data communications networks and protocols
- Databases
- Algorithms

While the details of their modes of use and assembling together vary across different particular marketplaces, they are understood and used in a similar way across the various settings. The structure and format of an electronic message may, for example, be different, but the concepts and techniques of electronic messaging will be shared even in very different implementations.

It is this common ground, created partly with the initial introduction of ICTs to the settlement of securities transactions, that made possible the initial comparability among separate systems and rendered explicit, visible, and calculable the actions and operations needed to integrate them. With the introduction of ICTs to securities settlement, particular local settlement arrangements and frames had, to some degree, been standardised through their expression in ICT terms and even if many aspects remained different, an all-important initial degree of comparability was established.

Building on the standardising effect that resulted from the inscribing of the frames that circumscribe marketplace interactions using ICT elements and vocabularies, it has been a central strategy of the Euroclear initiative to bring about a harmonisation of the different practices relating to settlement, custody, payments, reference data, and tax found in the particular discrete marketplaces being integrated through the incremental consolidation of the ICT platforms of the constituent CSDs on to a single shared ICT system. At the core of this

strategy is the assumption that because of the shared language and techniques of ICTs and the integrability this fosters, it is much easier to take apart and recombine the ICT elements of the settlement system without having to radically alter or dismantle the 'hard' and highly valuable sociotechnical networks that are the existing securities marketplaces to be integrated.

To bring about the harmonisation necessary for these separate networks and market frames to be integrated, starting from the ICT-based platforms and working all the way up to the level of settlement and marketplace practices, the starting point is to achieve some sort of comparability through an inventory of what is equivalent and what is different and what needs to be done to *make* something 'like' something else.

These points can be seen in, for example, the planning for the first steps in the implementation of the SSE presented earlier in this chapter, which involved identifying the core functions of the existing platforms and incorporating them into the design of the SSE and mapping their interfaces with various other systems to the SSE.

Throughout the Euroclear market integration project, and all its various phases and strands, the presence of comparisons through which similarities, equivalences, differences, and equalities are identified, recorded, presented, discussed, explained, and operated on is a constant theme. It is out of this work that documentation with qualitative descriptions of the different settlement arrangements found in the different markets could be produced, consultation papers published, responses from market participants received, update papers issued, and final service descriptions produced.

The Market Advisory Committees, already discussed earlier in this chapter as part of the "Delivering a domestic market for Europe" conceptualisation of the Euroclear initiative, were one more mechanism through which local marketplace differences and similarities could be identified, the reasons for them understood, and proposals on how to achieve greater harmonisation and similarity pushed back down to the market framing and formatting the

participant's view of the issues involved, as the following quote from one of the project documents sets out:

> "Market Advisory Committees act as a primary source of consultation between the Euroclear group and the user communities on significant matters relating to their respective domestic markets. In addition to systems consolidation, Euroclear's Business Model requires significant harmonisation if the Domestic Service is to be more than a combination of segregated local service offerings. Euroclear is therefore working to harmonise the various practices for settlement, custody, payments, reference data and tax. This is achieved through active consultation and dialogue with the markets. The dialogue is paying off and the admirable efforts that clients have made to engage in this process have been a good investment."

From all these sources, results are extracted and ordered in documents, tables, spreadsheets, and even in a cross-market glossary (Euroclear 2006c). Tables are produced detailing the differences that exist between the existing settlement systems and what action needs to be taken to bring about a common arrangement[87]. In this way, what could be left the same and what needed to be changed became much more explicit and visible. Mappings, whether direct or following some kind of translation through specifically designed interfaces, could take place. Workflows and project schedules could be compiled and project teams assembled. Budgets and costs could be calculated and business cases made and judged.

Key harmonisation areas

Of central importance in this process of comparison, harmonisation, and standardisation across different frames was a consultation paper issued by Euroclear entitled "Harmonisation Fundamentals". In effect, this document can be seen as a high-level inventory of all the areas of difference between the five separate securities settlement frames to be integrated accompanied by some initial comments regarding how these differences might be resolved and the barriers and risks that the necessary actions might need to deal with.

The areas identified were:

[87] See Appendix

- Access rights
- Reference data
- Transaction Lifecycles
- Central bank money
- Corporate actions
- Securities financing
- Other key legal and regulatory considerations

Access Rights

Access rights are the "rules setting out who is eligible to have an account in the existing ... platforms" and were found to vary, both in their content and in the identity of the entities eligible.

While in Belgium and the UK any "natural or legal person" could participate in the settlement system subject to fulfilment of the admission criteria, in France and the Netherlands there were specific limitations that complicated the picture.

In France participants had to be approved by the Conseil des Marchés Financiers (CMF) and rules relating to the collection of tax and income payments were seen as barriers to remote access, as income payments on French securities were paid gross and as a result foreign holders of French securities would be obliged to appoint a French settlement system participant as a withholding tax agent to either apply any tax due or provide the appropriate tax relief[88].

In Holland, admission to the settlement system is limited through the Giro Transfer Securities Act to "credit institutions granted a European passport under EU directives and whose business consists of custody, management and administration of securities on behalf of third parties".

[88] Since 2003, the CMF has been subsumed into a new securities regulator, the Autorité des marchés financiers (AMF), established by the Financial Security Act of 1 August 2003 and bringing together the Commission des Opérations de Bourse (COB), the Conseil des Marchés Financiers (CMF) and the Conseil de Discipline de la Gestion Financière (CDGF).

Reference Data

This refers to the data that underpin all the processing performed by the CSDs assembled in the Euroclear group. Their standardisation was seen as representing "one of the major requirements of consolidation in the settlement arena" and one that relates most directly to the integration of ICTs and the platforms they are part of. A central place in this area and one that relates directly to the first steps of the integration of the platforms through the SSE is occupied by accounts data and account structures.

While some commonalities were found, there were also wide varieties in many areas among the different settlement systems to be integrated.

The main high-level objectives set out in relation to this area of harmonisation were:

- Standardisation of counterparty identification
- Standardisation of securities information in one securities master file
- Development of a single but flexible account structure able to map on to the existing account structures of the legacy systems during the first phase of the SSE.

The key characteristics of the account structures found across the five different legacy platforms to be integrated are summarised in the table that follows:

CSD	Account Structure
CIK (Belgium)	*Accounts* and *Sub-accounts* are operated by *Affiliates* who can establish sub-accounts to reflect their internal organisation and/or the origins of a trade (e.g. on/off exchange)
CREST (UK)	One or more *Member Accounts* are held by *Participants*, but the single *Cash Account* is always linked to the *Participant* and not the *Member Account*. *Member Accounts* can have three *Balance Types* (Available, ESCROW, Repo and Deposit Link)
Euroclear Bank (Belgium)	*Participants* have *Principle Accounts* and beneath these there can be one or more *Master Accounts*, one *Cash Account*, and one *Stock Account*. The accounts can have six *Balance Types* (Clearance, CLIC linkage pool, transfer in, transfer out, lent, borrowed).
Necigef (Netherlands)	There are two types of accounts: *Investor* and *Issuer*. Legally only omnibus accounts are provided for but a variety of sub-accounts can be setup for administrative purposes within the two account types. Investor sub-accounts can include custody, pledgor, and pledgee. Issuer sub-accounts can include new

	issues and lodgement accounts.
Sicovam (France)	*Participants* can have one or more *Sous-Comptes* within which there is a Solde-Titre (Stock Account) created dynamically. Two "qualities" of balance pools exist: Nature de Compte, which defines how securities within the position are held (of which there are 99 different balance types) and Indice de Collaterabilité de Pretabilité et de Garantabilité, which defines whether the stock can be lent or used as collateral with the Banque de France. In each Nature de Compte there are further subdivisions of balances due to revocable stock and repo balances.

Table 1: Summary of account types and structures across the five securities settlement systems to be integrated through the Euroclear Single Platform initiative

A number of areas for harmonisation of securities data were also highlighted. These included "the rationalisation of the different forms of classification of instrument types" that exist across the marketplaces to be integrated, the harmonisation of valuation approaches, how long a security can remain in an expired status, the use or not of decimal points, and the treatment of marketplace specific data such as the requirement for "nationality declarations" that allow the monitoring of non-domestic ownership of certain securities.

Transaction Lifecycles

This area of harmonisation relates to "book-entry transfers resulting from secondary market trades".

The high-level objectives set out for this area of harmonisation were:

- A common process flow irrespective of the source of the transaction (e.g. stock exchange feed, clearing house feed, matching engine, or direct input), the nationality of the security, or the type of instrument
- A common timetable during the settlement day
- Standardisation using ISO 15022 wherever possible
- Settlement finality/irrevocability of transfer at the moment of book entry
- The removal of any manual processes and paper from the process.

The Euroclear "Harmonisation Fundamentals" consultation paper says about this area of harmonisation:

"Although the core role of a settlement system is the same in all group countries (i.e. to carry out the movement of securities against cash), the manner in which they undertake this processing varies quite widely. An important general observation affecting most of these areas is that a large number of small-scale differences exist, often at the level of individual message fields. Other than those that are there by reason of legal or regulatory requirement, for example, these differences generally do not reflect any fundamental difference in market practice or policy. Accordingly, we believe that these issues will mostly be uncontroversial and should be relatively straightforward to resolve. Nevertheless, harmonisation in this area will require changes to be made on a small scale across a wide range of functions within the settlement domain, as all markets adapt to a new processing environment".

The main elements of a securities transaction and the changes necessary across the systems to be integrated are given in the following table.

Transaction element	Differences to be overcome
Instruction Input	Securities transactions and the settlement instructions that accompany them are generated by stock exchanges, clearing houses, matching engines, OTC trades, and directly by the transacting parties. The main harmonisation concerns relate to the different formats settlement instructions are generated in. These can range from proprietary file transfer mechanisms and ISO 15022 messages, to telex and paper forms. The key objective is to persuade all the external entities involved to move to a common format in the form of ISO messaging standards.
Matching	Matching checks there is agreement about the terms of the transaction between the transacting parties involved. Two ways of matching are found across the systems to be integrated. In the first, both parties must input the full details of the transaction, whereas in the second, one party enters the details and the other accepts or rejects them. Also, on some marketplaces some transfers (free of payment) do not require matching. There are also differences in relation to whether matching is considered binding or not, how matched transactions can be deleted or amended, and how long an unmatched transaction can remain in the system. Finally, there are also differences in matching criteria and what degree of discrepancies might be tolerated.
Settlement Windows	For transactions to settle, a number of resources, both external and internal to the settlement platforms have to be available. The transactions themselves can specify a date for settlement and are not necessarily processed as they are generated. It is therefore crucial that there is a common timetable across all the marketplaces to be integrated according to which all the resources necessary for the settlement of a particular transaction are available to the integrated system. The biggest issues here are that the different marketplaces all have different timetables and that during the day they have different times at which different settlement activities take place on the different platforms. Some of the platforms also allow night-time processing.
Instructions Management	All the platforms to be integrated offer some way of specifying a priority for the settlement of a transaction. As this is linked to the algorithms used for the processing of the transactions, it was expected that some degree of an initial de facto harmonisation would result from the adoption of a particular settlement

	algorithm in the design of the SSE.
Failed Instructions	All the platforms to be integrated provided some mechanism for the 'recycling' of transactions that have failed to settle because of the lack of availability, *at that particular point in time*, of some resource necessary for its conclusion. The thinking is that as other transactions are processed, the resource missing (cash/securities) may become available at the next point in time when the failed transaction comes up for settlement again. The main harmonisation issues arises because the different platforms use different recycling rules and mechanisms and lengths of time that an unsettled transaction can continue to be recycled. Some also provide the possibility of partial settlement of a transaction if all the resources necessary are not available.
Status Reporting	All the settlement systems have mechanisms for reporting the progress of a transaction from input to settlement, but there were significant differences in "timelines (e.g. real time or regular updates) and content" as well as in terms of format, all of which would need to be harmonised.
Archiving	Once a transaction has reached a final status, whatever that may be (e.g. settled or deleted), the data pertaining to that transaction needs to be stored. The length of time for which that data is available for enquiry varies from system to system, as does the mechanism by which the data is ultimately stored once it is deleted from the main system. This varies from jurisdiction to jurisdiction so it was expected that the integrated system would have to keep the data for the longest period required. .
Legal Issues	There are differences between the systems in terms of how they achieve finality and it was envisaged that the rules regarding the point at which ownership is transferred would need to be harmonised. In most group CSDs, ownership transfers at the point of settlement in the relevant CSD. In France, however, ownership is deemed to be transferred at the point of trade for stock exchange transactions and at the point of settlement for OTC transactions. Harmonisation is necessary to ensure legal certainty of transfer of ownership (especially in cases of the insolvency of a counterparty between trade date and settlement date) and has an impact on several processing and operational procedures. Another issue of concern was the need to deal with both registered and bearer securities.
Regulatory Compliance	In a number of the constituent marketplaces the settlement platform also has to provide mechanisms for the reporting of transactions to regulators (CREST, Euroclear Bank, Sicovam) and the tax authorities (CREST). They key issues relating to this area are whether the Single Platform should be used for transaction reporting at all and if it does, how this can be harmonised and standardised across marketplaces and jurisdictions. One other compliance issue has been the ability of the operator of the settlement platform to intervene to prevent a transaction from settling (e.g. in the case of a default, or a court order, or in the case of a corporate action). Existing mechanisms vary according to the jurisdiction involved and the triggering event.

Table 2: Transaction lifecycle harmonisation needs

Central Bank Money

As the central function of a securities settlement system is to ensure the problem-free delivery of securities in exchange for some kind of payment, any integrated platform must provide ways for both the securities and the payment

from one of the existing systems to be able to cross seamlessly and be accepted by a participant in one of the other systems.

To achieve this on the payment side of a transaction, the Euroclear plan was to provide system participants with a "single pool of liquidity that would enable them to:

- Manage their payments from one single cash account held either directly with one of the central banks in the jurisdictions covered by the Euroclear group or through a settlement bank (compensateur)
- Make and receive payments to any other Euroclear counterparty irrespective of the identity of the central bank, settlement bank or compensateur with which the counterparty holds a cash account

Furthermore, the new arrangement must "retain or improve current safeguards against systemic operational risk in group markets".

It was anticipated that the main harmonisation effort in relation to this would relate to "achieving facilities to enable payments ... between central banks" by working closely with the central banks in the group's marketplaces "to achieve a higher degree of compatibility and harmonisation between the central bank money payment mechanisms used [previously]".

One central difference in the existing mechanisms was the use or not or settlement banks on the payment side as in Holland and Belgium all system participants have accounts at their central banks while in France they can have either a central bank account or use the services of a settlement bank (compensateur) and in the UK all participants use settlement banks.

Also, in some of the marketplaces payment arrangements can vary according to whether a transaction originates from a stock exchange or is an OTC transaction and such discrepancies would have to be removed.

The time periods during which liquidity is provided by the various central banks also varies across the Euroclear marketplaces, "although there is an overlapping real-time daylight window in all group markets".

There are also differences that will need to be removed between the various constituent marketplaces "in the way in which collateral is provided to central banks in order to generate liquidity".

Finally, there differences in the actual interfaces of the central banks and the Euroclear CSDs in terms of data exchange formats, channels, and frequency.

Corporate Actions

Corporate actions refer to events linked to securities that may occur during the lifespan of a security either on fixed dates (e.g. dividend or interest payments, refunds) or on an ad hoc basis (e.g. stock-splits, rights issue, tender offers).

There are a number of areas of difference between the various constituent marketplaces identified by the Euroclear integration initiative that relate to corporate actions and that would need to be harmonised.

One important area of difference relates to the definition of the dates on which positions are confirmed at the end of the day to identify which parties will receive the entitlement (record date) or from which trading occurs on the underlying security without the entitlement (ex date). Differences in these definitions were identified both across marketplaces but also across different securities.

The different marketplaces also apply different rules and processes, both in terms of defining who is entitled to benefits and the processes for ensuring that any related movement of cash and/or stock takes place. There are also differences in relation to the tax treatment of corporate actions.

Another important area for harmonisation identified is the treatment of 'open' transactions involving a security for which a corporate action has taken place.

Finally, there are significant differences in the movement of data and instructions relating to corporate actions as in each marketplace issuers in collaboration with the CSDs developed their own models and in some cases paper forms are still required (e.g. in takeover acceptances in Ireland).

Securities Financing

Securities financing relates to the borrowing and lending of securities that may be necessary for transacting parties to be in a position to deliver the securities they are trading or to enable the settlement of a failing transaction.

It was found that "Given the existing compatibility of the services provided with the terms of the standardised lending and repo agreements, there is already a high level of harmonisation in this area at the level of principle and overall functionality" but that there remained "some differences in the detail of the functionality that need to be addressed and harmonised before a single solution can be identified for each area".

Other Key Legal And Regulatory Considerations

In this category, the Euroclear developers placed "a number of areas where the harmonisation of CSD functions and market practices is dependent on changes in legal, regulatory or fiscal requirements".

These were found to fall in two broad categories:

- Requirements for local presence
- Laws and regulations that do not recognise multi-intermediary settlement chains

According to Euroclear, "ideally, common legal frameworks would be put in place in the group jurisdictions to support all aspects of harmonisation and cross-border holding and settlement".

The sociotechnical work of marketplace reconfiguration

What emerges from this meticulous, detailed, and systematic work of description, comparison, classification, harmonisation and proposed standardisation is an inventory of social and technical aspects of the settlement systems to be modified and new entities to be put in place for integration to be achieved.

The elements to be modified and the new ones to be introduced in the process are both social and technological. ICT integration was only one of the strands that needed to be woven together in the proposed marketplace integration initiative, as a consultation paper issued by Euroclear after the publication of the "Delivering a domestic market for Europe" document outlining further details of the plan explains:

> "It is clear that a sufficient level of harmonisation of market practices, rules, and services is critical, to reap the full benefit of the platform consolidation. ... Without it the Domestic Service will remain a combination of segregated local packages, preventing the users of the group from streamlining their own domestic back-office processing chains across all securities and thereby missing the opportunity of rationalising and simplifying their back offices and of realising significant additional cost savings."[89]

In a separate consultation paper presenting the "roadmap" for the Euroclear initiative, areas of further harmonisation beyond those involved in the immediate integration of the ICT platforms are indicated:

> "In addition, it is clear that market participants increasingly support the harmonisation of regulatory, tax, and legal rules across European markets although these are, of course, matters that will require legislative or regulatory action."[90]

The integration of ICT elements and platforms is a necessary ingredient but one that needs to be combined with a number of others, as one of the interviewees from the Euroclear division in charge of the integration initiative explains:

---

[89] In (Euroclear 2003b, p.16)
[90] In (Euroclear 2003c)

> "How do you migrate essentially five [marketplaces] in terms of their processing and in terms of their technology - the actual hardware and software - how do you migrate that on to this single rationalised platform? One option would be just to say: "well, actually, we'll just take the existing rules in each of the five markets and throw all of those on to a single piece of software running on a single piece of hardware". That has a number of advantages. You can just do that in the background, you do not need any kind of market acceptance of that. You just take the existing market rules and migrate them to a single platform. What you wouldn't do then, is realise the benefits for [market participants] in quite the same way. Because [although] you could still probably get rid of [the] physical communications links and you could still have, probably, one set of messages to deal with the Euroclear group markets, what you [still] have to do is have a load of business rules that the [market participants still] have to maintain at their end, [along the lines of]: "if it is the French market I do this and then do this; if it is the UK market I do this, I do this, and I don't do this", etc. So he has additional complexity, he [still] has to maintain four systems. What he can't do is that headcount reduction, because he will still have to have [all those relationships] and specialisations. Knowing [for example] that the French tax laws are different than corporation tax is in the UK. [All this] is absolutely key, because without that element it would be a simple rationalisation. It would be taking a set of existing systems and replicating them in one sort of physical platform, which – fine, it is a massive task - but it would be unrelated to this harmonisation."

The sociotechnical character of the integration of five separate financial marketplaces could also be seen in the four strands of the project as presented in the Euroclear plans. The following timeline diagram from the Euroclear consultation paper "The Harmonisation Roadmap", updates of which were to be found in the introductory sections of all subsequent project-related documentation, illustrates this.

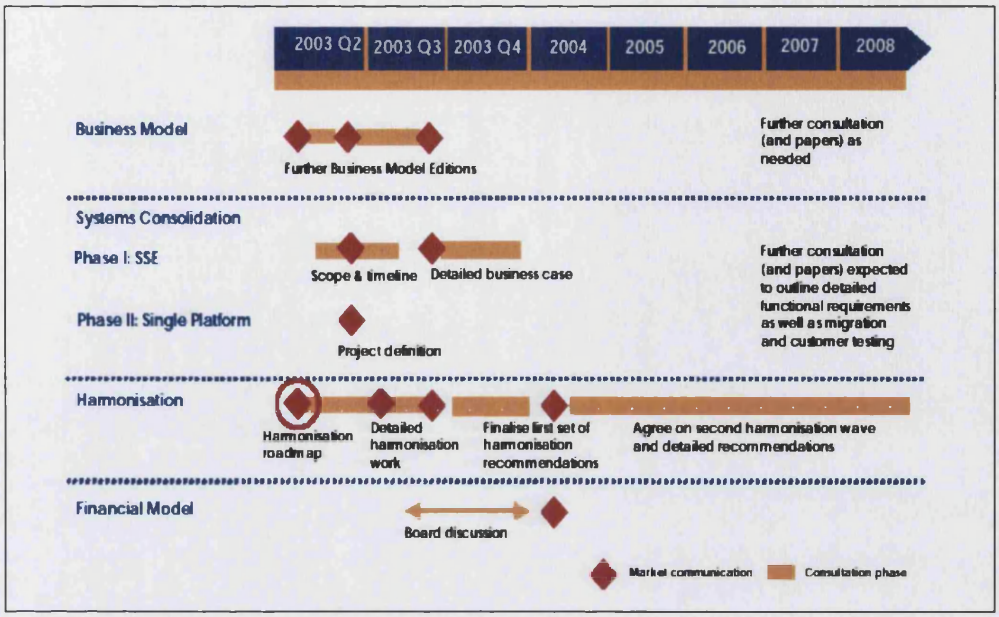

Figure 9: Timeline diagram highlighting the various consultation phases for the major streams that compose the Euroclear marketplace integration initiative (source: Euroclear)

The Business Model stream was seen as covering "the key functional, legal, and pricing considerations which, taken together, describe the services that will be offered" as a result of the successful conclusion of the marketplace integration initiative (Euroclear 2003d, p.7).

The Systems Consolidation stream was concerned with particular technical, functional, legal, and regulatory considerations relating to the "successful delivery of the SSE" and all the other ICT-related elements of the Single Platform such as the Common Communications Interface (CCI) (Euroclear 2003d, p.8).

The Harmonisation stream addressed the harmonisation of broader market practices, rules, and services necessitating the involvement of "markets and market players, including but not limited to central banks, regulators, stock exchanges, and central counterparties" (Euroclear 2003d, p.9).

Finally, the Financial Model strand was concerned with how the implementation of the marketplace integration initiative "will impact Euroclear's corporate and financial structures" (Euroclear 2003d, p.10). This would include issues such as the appropriate "corporate structure to cater for

shared systems and services, including the ownership of the consolidated platform, the "elaboration of a clear and detailed transfer pricing and cost allocation methodology among corporate entities" regarding the financing of the necessary investment in the initiative, and a "clear articulation of the financial policies of the group" regarding service pricing and the allocation of dividends and rebates (Euroclear 2003d, p.10).

Furthermore, as the initiative unfolded and took shape, actions would often cut across categories, not only underlying further the sociotechnical character of financial marketplace integration, but also making visible the interrelations between the social and technical elements and how these needed to be fitted together. Even in the Systems Consolidation stream dealing specifically with the integration of ICT elements and systems, legal and regulatory issues were fund to be an integral part of the development effort.

ICTs and the disassembling and recombining of market frames

What was observed from following the Euroclear initiative was that the importance of ICTs was in the central role they played in the intricate re-articulation process presented previously. This role will now be examined and described in more detail.

Once the corporate integration that brought together all the CSDs that now form the Euroclear group had taken place, ICTs, in the form of the Single Settlement Engine (SSE), were to be used to provide the first links bridging the "structural holes" among the separate sociotechncial networks each entity brought to the group in an internal, functional, and less contestable way. With these links in place, not only would the proposed integration plan gain a significant degree of materiality through the realisation of significant network effects and economies of scale as flows of transactions started to go over them, but many more details of further harmonisation and standardisation efforts needed that could not be known when designing and planning the new platform would also render visible and more explicit. The Euroclear business plan for the Systems Consolidation stream of the integration initiative writes about this:

> "Development and implementation of the first phase of Systems Consolidation (the SSE) can be completed without the need for significant harmonisation of market practices. Once the SSE is in place, subsequent phases can be defined as the outcome of the harmonisation initiatives becomes clearer".

By forming the initial functional bridge between the five existing market frames to be integrated, the SSE was a central element in a strategy of marketplace re-articulation from the inside outwards, as described by a senior member of the Euroclear team involved in the development of the SSE:

> "The strategy was to move [out] from ... the technological layer which is the SSE and which is fully within our control and which we use to get transactions sent to us by clients using various messaging interfaces, to operate on their positions, [and] once we have received and validated and matched these instructions, actually the processing of those, either three days later or whenever, depending on the trade date and the settlement date. All this is very much in our control. That was precisely why the SSE was picked as the first step. So when ... the mergers more or less finished ... with the merger with CREST[Co], the first step that was taken was really one to build momentum and to try and address some of the elements of harmonisation and consolidating that could be addressed [and] that could be much more heavily controlled by ourselves, notably book-entry settlement that is something that happens very much at the back end. ... We were aware that market harmonisation on the kind of scale we were looking at, across four very very different domestic markets plus also the ICSD, which again had very different drivers, that harmonisation was going to be a lengthy and painful process. And so we were looking for something that we could begin with, first of all to get our own internal kitchen working. So the SSE was an opportunity to start doing that."

In another interview at Euroclear, the same point was made in a slightly different way:

> "With the [core settlement process] everyone kind of agrees that essentially ... once you've got your transactions agreed and matched at the CSD and I have got all the resources I need then that will effect a DvP transaction. ... If you ask any businessperson they don't care. They will say: "I care about the legal implications of matching; I care about what is going to happen on a dividend; when I get my cash. ... I can see you've got 98% settlement completion. I don't really care. I just want something settled". So there is far less business input into this element than there is in all the ... others. So this looks like - and I kind of artificially separated it out - it looks like a good candidate for something that the group could do early, without requiring extensive market input into the harmonisation process. So that was key. Because, what the group felt was very important to do was to get some momentum into the process and to begin

> [work] immediately on merging. ... I think it was very important to begin to show that we were actually consolidating straight away. But this was representing an element that without extensive market input could be done. We didn't [need to] go to the market and say: "what would you like to do about the queuing algorithm" or "what would you like to do about how we do technical netting". ... The market response was very simple: "We want the stuff to settle and if stuff didn't settle, then we want you to try and do something about it." And that is a very high level requirement. It is held to be, not paramount, but pretty obvious. Therefore, much less market consultation was required there."

A further reason for starting the integration process from the ICTs and the settlement platforms they underpin was the standardisation and harmonisation introduced to securities settlement by the past moves to ICT-based settlement systems with the dematerialisation of securities as discussed previously.

With ICTs, the task of connecting and assembling disparate sociotechnical components is much more straightforward. Electronic messages can be translated to make possible communication between diverse formats and differently configured applications. Dissimilar database fields can be mapped to each other in a way that establishes a correspondence so that the data exchanged can maintain its meanings and uses across different frames.

Once a market frame had been inscribed into an ICT-based platform, marketplace reconfiguration and the re-framing of securities transactions necessary to enable these to take place across different jurisdictions could be approached from an ICT perspective using established techniques developed for the interfacing and integrating of ICT systems and components. This allowed the Euroclear designer of the new common market frame to consider the possibility of achieving the first cross-frame linkages through the disassembling and (re)combining in different ways of both existing and newly developed elements and components of ICT-based settlement platforms and without the need – initially – for extensive legislative and regulatory redrafting[91]. In effect, the existing national legal and regulatory provisions for the trading of securities were to be used as building blocks and components of

[91] Apart from the EU Settlement Finality Directive that was passed in order to standardise across the EU the point in a securities transaction when finality is legally defined and an exchange is considered legally binding, there were no major legislative or regulatory changes required in the Euroclear market integration initiative

the new cross-border system as would the ICT platforms already in use, even though their core DvP functions would be carved-out and outsourced to the SSE, as will be seen.

The SSE and the re-articulation of practices, legislation, and ICTs

While examples of all these points can be found in all the phases and strands of the development of the Single Platform, the development of the SSE provides the most interesting illustration, both because it has reach completion but also because of its centrality in the bridging the different local market frames to be integrated.

The SSE was a crucial component in the market integration initiative undertaken by Euroclear. It would be through this that the book-entry transfer of securities against cash, the most fundamental step in the settlement of securities transactions, would be made possible across the five different market frames being integrated. Once cross-marketplace book entry transfer was in place, a legally-backed unbroken chain of reference could exist between transacting parties across the five different marketplaces to be integrated and the objects being exchanges, in this case securities and cash, could cross seamlessly between the transacting parties without any of the properties of these objects having to be altered or given up.

The thinking behind the SSE was that despite differences in a number of implementation details, all the settlement platforms to be integrated share this book-entry transfer function in more-or-less the same configuration. It was therefore possible, with a "limited amount of technical harmonisation" and little need for extensive stakeholder consultation and disruption of existing marketplace interactions, to put in place a keystone of the integrated settlement system being assembled that would create the first concrete connection linking the until then separate marketplaces and allowing the flow of transactions between them.

In effect, the existing DvP mechanisms of the separate legacy platforms would be removed and a common process designed and inscribed into an ICT system

to which the remaining parts of the legacy platforms would 'outsource' their DvP processing. In this way, the many much more complex and contestable areas of harmonisation that would need to be resolved before being able to move towards a single settlement system could be left aside and accommodated through the continuing presence of the remaining parts of the legacy platforms. With this approach, while a certain degree of cross-platform technical harmonisation is achieved through the development of the SSE, many differences in practices, processes and rules that persist can still be dealt with, as the following example from the Euroclear "Business Plan for Systems Consolidation" document illustrates:

> "The method of calculating available credit facility varies from market to market, but there is a single calculation in the SSE, with the number of components utilised depending on the calculation required."[92]

Furthermore, many of the elements defining the character of the individual marketplaces being integrated (e.g. the securities themselves and the legal and regulatory frameworks that give rise to them) could be used as building blocks for the new integrated system, thus maintaining the link between the new integrated marketplace and the five constituent marketplaces and the networks they were part of.

Assembling the SSE

The central function in securities settlement, Delivery versus Payment (DvP,) is achieved in an incontestable way by ensuring that "payment finality coincides with final transfer of securities [ownership] enforceable against third parties" (Euroclear 2003e, p.20). Since the SSE has to accomplish that for five different platforms, it has to be able to cope with five different sets of securities, account structures, and cash records. The Euroclear "Business Plan for Systems Consolidation" document writes about this:

> "The SSE will implement an account structure compatible with all existing CSD structures and will operate securities and cash balances and credit positions within this structure."[93]

---

[92] (Euroclear 2003a, p.12)
[93] (Euroclear 2003a, p.12)

When a transaction in any of the constituent CSD legacy platforms is ready to settle, in other words, when all pre-settlement actions and matching have taken place as per the legacy system provisions and a transaction's settlement date has been reached, the legacy platform would submit the transaction to the SSE for further processing.

The SSE would then need to determine which transactions can settle in compliance with instructions from the particular CSD using information on the balances of securities and cash or credit/collateral which customers hold through their local group CSD. This way the SSE would determine whether the counterparties to the transaction have the necessary resources to settle.

Once the SSE has determined which transactions have resources available to settle, it blocks the availability of the positioned securities and cash, books the cash updates *provisionally* in its *own* database and sends a message to the relevant *local record* requesting a *definitive booking* of the securities transfer. At the point at which the local record is updated, the settlement process (i.e. the transfer of title to securities and payment between the parties), is final – that is, irrevocable and unconditional.

When the local record *responds* to the SSE to *confirm* the update, the SSE updates its *own records*, recording the cash movement as definitive and reports the movements back to the CSD that sent the transaction. This then generates the normal reports to customers and other parties (e.g. central banks and external registrars)[94].

As part of the assembling of the SSE, a new common settlement algorithm was developed to determine the sequence in which available resources would be allocated to the transactions received for settlement from the legacy platforms. One key difference with some of the legacy platforms was that the resource allocation is performed in sequence and if the resource being considered is

[94] The SSE responds to a group CSD only when a transaction has settled or has failed to settle. In the latter case, the SSE will also report the reasons for the failure. There is no reporting on interim steps. Similarly, a CSD report to customers will only show that transactions have moved from unsettled to settled status.

insufficient to settle the transaction, further resources are not examined and a failure reason is generated for that particular settlement attempt[95]. Resources are checked for:

- Sufficient availability of the relevant securities in the transferor's relevant member account
- Sufficient 'headroom' within the relevant cap of the transferor
- Sufficient headroom within the relevant cap of the transferee
- Sufficient liquidity on the transferee's Real Time Gross Settlement (RTGS) settlement bank's Liquidity Management Account (LMA)
- Sufficient liquidity on the transferor's RTGS settlement bank's LMA
- The possibility that settlement might breach a sponsored member's net settlement limit

Assuming all are available, the SSE then allocates resources sequentially for each transaction as follows:

- Securities movement
- Cash movement
- Liquidity movement
- Net settlement position

As soon as the resources are irrevocably transferred between the transacting parties, finality is achieved and securities, cash and/or credit become immediately available for further settlement purposes.

The adoption of a common new algorithm across platforms implied certain changes for all group systems in the precise ordering of transactions for settlement. It is based, however, on "the same criteria as are currently used –

[95] In the UK CREST system, for example, the availability of resources is considered in parallel and not in sequence.

customer priorities, in particular, but also, for example, the size and age of the transaction"[96].

The new algorithm also incorporates "a number of optimisation tools, aimed at analysing groups of transactions as a whole, to increase settlement efficiency and settle gridlocked transactions whilst minimising risk and credit usage" (CRESTCo 2006, p.21).

CREST for example, used a repeating cycle of settlement, where all resources were allocated in parallel, followed by a period of settlement for any transaction for which all resources were present. The SSE settlement algorithm that will apply to all group CSDs works on the basis of attempting to settle each transaction in turn, with dynamic recycling of failed transfers. A senior member of the Business Model and Harmonisation team at Euroclear involved in the development of the SSE explains:

> "The one thing we did have to harmonise [with the SSE] was the exact mechanics of settlement. So, for example, CREST used to use a parallel set of processes. We would have the securities queues, the stock queues, the cash queues, and it would have a lot of parallel processing and each type of resource would have its own rules about the order in which they would be tried, and there was liquidity as well, so there were a number of things going on in parallel. The way liquidity was prioritised was different to the way securities stocks usage was prioritised. And that was fine and worked for CREST and it had the mini cycles that took advantage of those. But the SSE was designed along the lines that Euroclear Bank used at the time, which was to have a monolithic ... single threaded process running on a very fast machine and everything loaded into memory. So it was very fast. No disk access and the rest. It would flash through this threaded process, this single queue of transactions, very very fast. And now that the SSE is in, we can breath a little sigh of relief. Quite apart from any little issues that the SSE had, the one thing that it [does have], that is has genuinely stood up to, is the

[96] Transactions are presented for settlement according to the following criteria: First transactions in self-collateralising repo-eligible securities, then according to random security number, then according to the stock debit priority entered by the receiver of the securities, then by intended settlement date (instructions starting with the oldest settlement dates will be treated before same priority instructions with a more recent settlement date), and finally by the value of the securities or cash involved. The use of random securities numbers for the prioritisation of transactions is to avoid favouring one security over another in the accessing of credit/liquidity resource. The SSE attributes a random number to each security in its reference database every day and instructions are then sequenced by these random numbers, starting with the highest.

> volume. And it processes very very fast indeed. So it is a very different approach but it achieves the same thing. But is also completely different."

Part of this algorithmic harmonisation also relates to the way transactions that are failing to settle are dealt with. The same Euroclear interviewee talking about this aspect of the SSE, said:

> "There is this thing in CREST called 'circles', which is where we try and resolve settlement failures at a certain point in the day. We say, that for every transaction that's currently outstanding and could settle but hasn't, we look at those in a sort of macro view and we see that if we net some of them off we can do the positioning in a netted way, but still settle gross. It's *not* a netted settlement, but it's a *netted positioning*. And each market had a very different approach to how this was done. For example, Euroclear Bank, when it found any of these failures, as it found a failure it would very quickly, for that particular failure, go and look and see if there was something that was similar, going the other way."

Two mechanisms have been built into the SSE for dealing with failing instructions: 'Recycling' and 'Technical Netting'. Recycling is the process of trying to "reposition [in the settlement sequence] a previously failed instruction in the hope that the repositioning will be successful". With the dynamic recycling used in the SSE, the settlement process immediately "retries one or more previously failed instructions when an event occurs that might allow a new positioning attempt to be successful". Failed instructions get automatically recycled throughout the day, "pending the availability of the required resources"[97].

'Technical Netting' is the settlement optimisation algorithm developed for the SSE. It is not a batch process and therefore does not require settlement to be suspended in order to identify gridlocked transactions. The algorithm analyses all failed transactions at the SSE and links these all together in an attempt to identify and suggest nets (i.e. transactions that may cancel each other out). The failed transactions are sent to the SSE for positioning as *linked transactions*. If any of the transactions have settled they are removed from the net. The

[97] Recycling gives no guarantee that positioning will be successful. The decision to recycle only reflects that there has been a change since the last attempt, which may mean that another attempt might be successful.

remaining transactions stay in the net, and through their relative positioning in relation to each other, the algorithm will attempt to settle them. If the resulting 'net' fails to settle, the process of identifying technical nets is resumed. The netting process will run at specified limited times during the day.

The transferring of legal title in the SSE

The account of the development the SSE and some of its key features presented here helps to illustrate the links between harmonisation and the use of ICTs for the disassembling and recombining of new and existing social and technical components and elements of the settlement systems to be integrated. This re-articulation of the social and the technical becomes even more visible and explicit in the way the SSE links the different jurisdictions that the consolidated Euroclear group straddles.

Looking back at the UK's CREST settlement system, both the Settlement Processor and the Operator Register, the database where legal title to ownership is conferred, resided on CREST. In this arrangement, an entry in the Member's stock account was considered as proof of ownership[98]. The Operator Register foreseen in the relevant legislation was represented by the database in CREST with all these accounts. This arrangement is illustrated in the diagram below:

[98] See Appendix E for details of the CREST platform and the account structures it used.

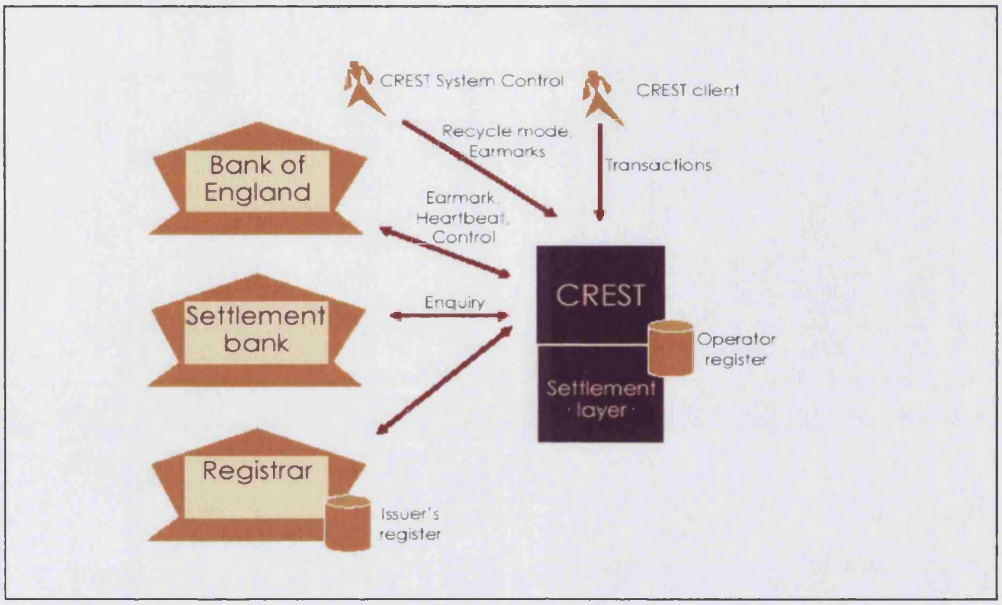

Figure 10: Transfer of legal title to securities in CREST before the introduction of the SSE (source: Euroclear)

With the introduction of the SSE, the settlement processor used by CREST will be located not only outside the CREST platform but also outside the borders of the UK. The legal requirement for the Operator Register to be in the UK still remains, however[99]. The Euroclear interviewee involved in the design of the SSE and quoted earlier, said about this requirement:

> "I would say that was quite a surprise for us, once we started. Because we just assumed – I think quite naively – when we very first started, because there were no lawyers present, [that] it would be just a simple case of having a Single Engine. But as soon as we consulted with the legal side they said: "no, in fact that is wrong"."

In order to be able to maintain the full range of property rights that define securities as objects of exchange but entangle them in specific jurisdictional spaces, the designers of the new cross-border settlement system had to find some way of preserving the link of the securities with the jurisdictions that define them, while finding a way of disentangling their actual settlement process from that same jurisdictional space. The high-level systems architecture similarities of the legacy settlement platforms following the introduction of ICTs and the use of ICT interfacing and integration techniques

[99] According to UK company law, a company incorporated in the UK must have its shares register in the UK. Because for uncertified securities the CREST securities accounts are considered as the official share register, these have to physically reside in UK jurisdiction.

made such a task possible and enabled the designers of the new system to gradually take apart the existing arrangements and build with both new and existing components the new cross-border settlement system.

To meet this requirement in practice meant there had to be a securities database located in the UK, which would hold member's account balances, even if settlement itself took place in a shared common system outside UK jurisdiction. Transfer of legal title would then be constituted by movements on this local database and, in the event of a discrepancy with the SSE, the records of the local database would prevail. The SSE itself would "hold copies of these records for processing, reconciliation and audit purposes" but such records would be "mirror" records of those in the particular national jurisdiction and used for processing purposes.

At the same time, the finality of the transfer of the cash and the finality of the transfer of the securities must occur simultaneously to meet the requirements of settlement models with immediate finality. As described previously, on the SSE this is achieved by generating the cash records with finality conditional upon the generation of the securities records on what is being called in this initiative the local 'Legal Record'.

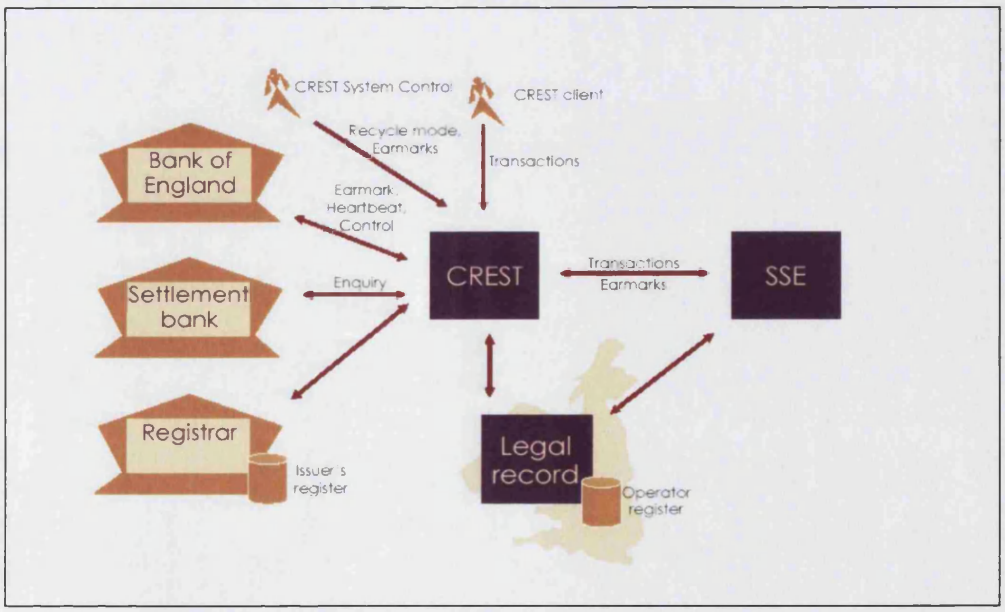

Figure 11: Transfer of legal title to securities in CREST after the introduction of the SSE (source: Euroclear)

As can be seen, with the introduction of the SSE there is initially no real change to the fundamental architecture of CREST. Simply CREST itself communicates with the common SSE shared with the other settlement platforms of the Euroclear group rather than its own internal Settlement Processor. The settlement functionality (checking and positioning of resources, sequencing of transactions, movement of securities and cash, optimisation), as outlined in previous section, is moved to the SSE, but the Operator Register, which has to be maintained within the jurisdictional borders of the UK, is no longer the Member securities account database (now be part of the SSE), but a new, separate, database that resides within UK jurisdiction, the Legal Record. As the SSE processes a transaction, at the point where the amendments to the securities and cash accounts of the transacting parties is ready to take place, the SSE will also attempt to update the Legal Record in the jurisdiction of the securities being transacted. As DvP takes place with the update of the Legal Record, the jurisdictional requirements for the securities being transacted are fulfilled.

Although the new account structures and databases for the SSE were developed in such a way as to ensure that as many common features as possible with those in the existing legacy platforms were included in them, where that was not possible, some kind of equivalence and mapping between the existing and new structures had to be established. Critical to this was the development of a specially formulated set of electronic messages for communication between the legacy settlement platforms and the SSE, developed in such a way that easy interfacing could be achieved and the process of disassembling and (re)combining facilitated. The person responsible for ISO Standards at Euroclear, who is quoted at some length as the point he makes is crucial to understanding this process of disassembling and re-combining observed in the development of the SSE, describes this work as follows:

> "We knew [messaging] was absolutely critical and that communications are always the key. ... We set up separate projects. We had the core SSE project that was actually building the engine and it was totally their responsibility to define their interface. What we came up with was the

> SSE DEXs based on the CREST DEXs (Data Exchange Messages). So the SSE DEX – that contained all of the information and messages that the SSE needed to function. Obviously the CSDs ... due to make changes were able to challenge and say: "we can't do that, can we do it this way", but essentially it was down to the core SSE to define the single interface to it and it was up to the CSD projects to connect [to] it in this way. Again that becomes, it is almost like the SSE is being a CSD and the CSDs are its clients. It was being very prescriptive. And while consultation was done, it was down to the SSE to lay it on the line and say: "this is a format and a message I want to receive". You would be surprised at the large number [of messages]. ... There are messages to send transactions, messages to record transactions, to change the priority of the transactions, there are messages to [access] the reference data because it needs to make decisions on the reference data, get the securities reference data down there, get credit reference data down there, get account structure data down there. You need to know the structure of the account and who owns what. That all has to go on, on a daily basis. There are diary events, when a settlement window opens and when it closes. That information has to go down to the SSE. There is information about technical netting and – you know – the 'circles' process that CREST used to run. There [are] all sorts. ... There was a significant amount of technical work there. It is a good 300-400 page document. It is not insignificant. And there is another very interesting point, which is that CREST hitherto hadn't had a distributed database. It had a big single database that it could completely control. All of a sudden it had its own local database and the SSE database and having this split in the database and asynchronous updates, sometimes here and sometimes there, that [brought up] a whole new set of issues."

With the Legal Record and common account structures for both securities and payments in place at the SSE, it becomes possible to see how a cross-marketplace transaction between *all* group customers in *any* securities held within group CSDs, regardless of the jurisdiction, can be transformed into an internal book-entry transfer.

In the first phase of its operation, while the SSE would be in charge of the *technical operation* of cash and credit facilities, the *contractual responsibilities* remain with each of the individual CSDs and "each set of securities held in the CSDs remains subject to local asset protection and transfer legislation" (Euroclear 2003e)[100]. This means that during this phase, before the Single Platform and much of the other harmonisation in settlement practices and

[100] The relationship between the CSDs and the operator of the SSE is to be structured as a "contract for the provision of services, whereby each of the group CSDs will outsource parts of its IT processing to the SSE operator" and similar to third party outsourcing arrangements for IT services "already in place with Euroclear Netherlands and CRESTCo" (Euroclear 2003e, p.17).

processes necessary for the full integration of the different constituent settlement arrangements is in place, customers would hold securities from group marketplaces other than their own through their local CSD in an omnibus account that this local CSD holds in the 'home' CSD of these securities. It is envisaged that in the second phase of the SSE such omnibus holdings of group securities will have been replaced by direct holdings of the securities in *their* home jurisdiction by settlement system participants from the other CSDs.

The key difference between a cross-border and domestic transfer during the first phase of the SSE is that instead of the movement of the securities in the local Legal Record of the seller's jurisdiction taking place between the accounts of two local transacting parties, it takes place between the account of the seller and the 'omnibus' account in that jurisdiction of the CSD of the buyer's jurisdiction[101]. Final payment takes place at the time of generation of these records on the local Legal Record database so that it coincides with a final transfer of ownership to the securities. The local Legal Record database of the seller's marketplace then sends a message to the local Legal Record of the buyer's marketplace that then updates its own legal records, reflecting the movement of the securities being acquired from a 'mirror' account of the omnibus account of the buyer's CSD at the 'home' CSD of the seller, to the account of the buyer. Then, following update of its records, the local record of holding of the buyer's market sends a confirmation message back to the SSE that then updates its cash and securities records, releases the securities and cash for re-use and starts processing the next transaction.

Although in practice the SSE is performing a series of sequential steps it only reports back once all these steps are complete. The SSE thus handles all the complexity of properly sequencing intra-group transactions between systems in a way that is 'invisible' to clients, so that from their perspective the transaction

[101] An 'omnibus account' is defined in the "Glossary of terms relative to securities clearing, settlement and custody in Euroclear" as follows: "A single account for the commingled funds or positions of multiple parties. A clearing member will often maintain an omnibus account at the clearinghouse for all of the clearing member's clients. In this case, the clearing member is responsible for maintaining account records for individual clients."

are settled as one unit like any other domestic transaction. Consequently, settlement between customers of the two still separate legacy systems achieve DvP and the cash and securities received in settlement are available to the transacting parties simultaneously and immediately upon the completion of the updates to the SSE. This offers significant improvements in cross-border transfers compared to how they were undertaken previously and which typically took much longer to settle[102].

Cross-border payments in the SSE

In addition to the transfer of securities, arrangements have to be put in place for the payment side of cross-border transactions. In all the Euroclear legacy settlement systems, whether directly through accounts held at the central bank of a particular jurisdiction or through settlement banks with an account at the central bank, payments for securities transactions were effected through the use of central bank money payment mechanisms.

To enable transacting parties within one central bank regime to make payment to those in another "without requiring cash correspondent relationships to be opened", Euroclear have had to work with the central banks of the group's jurisdictions "to develop a mechanism for coordinating the transfer of cash between these markets through cross-central bank transfers".

The approach chosen for the SSE is that each central bank will act "as a correspondent of the other [central bank] for the purpose of [making] central bank payments" from one jurisdiction to another.

In general, central banks give CSDs control over determining the moment at which transfer of cash takes place as countervalue to a securities transfer. Euroclear has aimed to "maintain the same principle though now achieving finality within the process delegated to the SSE".

[102] It was not unusual for delays of several hours to occur for confirmations of settlement to be passed between two CSDs and during this time the cash or securities involved would be unavailable to one or both customers because even when one counterparty had exchanged securities for cash, the counterparty in the other CSD would be unable to get access to the countervalue until the confirmation has been processed by both CSDs.

To achieve this, a "system of correspondent accounts between the central banks" that will enable the SSE to make "definitive cash entries corresponding to the securities movements" has been devised. This arrangement is based on the establishment of correspondent accounts between the central banks on the SSE that the SSE will operate and that will enable simultaneous payment between transacting parties in different jurisdictions via their existing local central bank payment structures[103].

In practice this means that when a buyer of securities from one jurisdiction wants to acquire securities from a counterparty in one of the other Euroclear jurisdictions, the account on the SSE of the buyer or the buyer's settlement bank will be debited by the SSE and the amount then credited to the correspondent account of the seller's central bank on the SSE. At the same time, the correspondent account of the buyer's central bank on the SSE is debited and the same amount is credited to the seller's account in the SSE. In effect what has happened is that while the two transacting parties have concluded a payment in central bank money from one to the other backed by the creditworthiness of the two central banks, the two central banks have acquired an obligation to each other in the process that they will discharge "at the end of the day or at points throughout the day by net payments effected through TARGET (or TARGET2 in the future)"[104].

The SSE payment mechanism is illustrated in the following diagram using the example of a Dutch settlement system participant selling Dutch securities to a French counterparty.

[103] In some marketplaces, central bank money is transferred into an account operated by the CSD; whereas in others the CSD simply records the amount of central bank money reserved by transacting parties or their banks for settlement purposes.
[104] TARGET and TARGET 2 are the inter-central bank payment systems developed for the Eurozone and operated by the European Central Bank following the launch of the Euro.

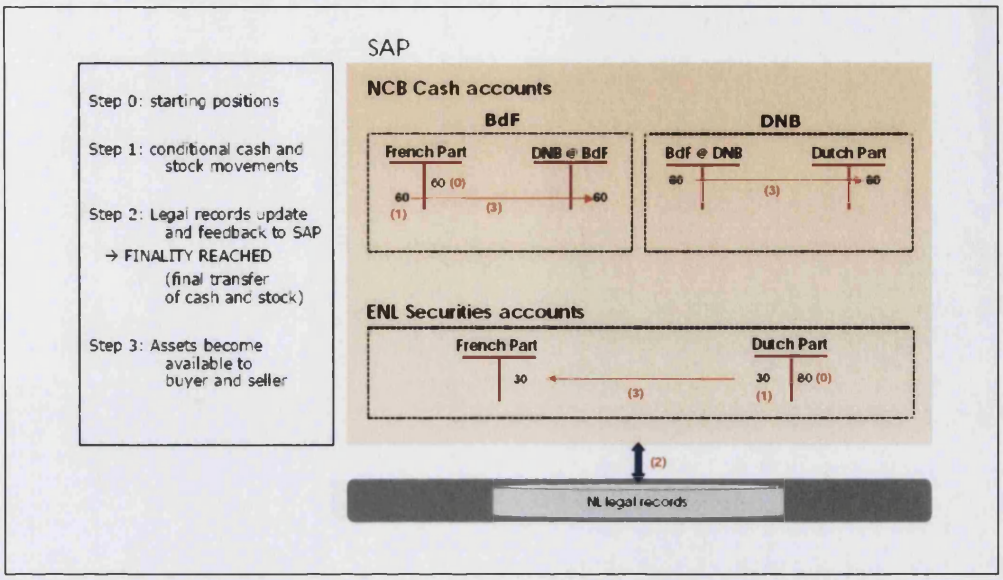

Figure 12: Example of the cross-border payment mechanism developed for the SSE illustrating a transaction between a Dutch participant selling Dutch securities to a French counterparty (source: Euroclear)

The steps taken by the SSE are as follows and occur simultaneously:

- The availability of securities in the Dutch client's account is checked
- The availability of central bank money liquidity in the French client's account is checked
- Conditional cash movements are executed
- The transfer of securities and the subsequent updates on the local legal records is effected;
- The securities are moved from the Dutch client's account to the French client's account
- The liquidity is moved from the French client's account at Banque de France (BdF) to the De Nederlandsche Bank (DNB) correspondent account in BdF and from the BdF correspondent account in DNB to the Dutch client account (at DNB).

Interfacing and the material interrogation of existing structures

As the cross-marketplace settlement platform is being developed, it is not just the relations of components internal to the systems that have to be re-

articulated. As has been shown, a settlement platform structures both the relations between elements that are a part of it as well as those with other external sociotechnical assemblages and the entities that comprise them (e.g. payment and banking systems, regulators, legal and tax systems, and the wider financial services industry).

With the SSE launched with Euroclear France on 29 May 2006 and CREST on 28 August 2006 and going live with Euroclear Bank at the end of 2006, a durable material entity has emerged and taken shape. This now concrete entity poses questions to the world around it, interrogating the existing structures it must fit with.

The SSE prescribes very precisely how what is outside it must interact with what is inside it and, once in place, it is no longer easy to change and alter. This new arrangement of human and non-human entities starts to set limits on possible events (Barry 2002). It is then down to interfacing or by designing specifically for – or around – these precise requirements that other external elements and networks can be attached to it.

As the interfacing and assembling moves outwards from the algorithmic core of the emerging common platform, it gets more complex and fraught as more and more elements are linked to it with there own prescriptions of how the world outside them should link with them. The entry points to the new 'inside' of the system proliferate. Not only does complexity increase as the number of elements linked increases, but as more and more actants are brought together with their own scripts and programmes of action, so does the control of the designers start to wane.

Seen in this light, the SSE is not only important in terms of illustrating the importance of the notion of comparability or the use of ICT interfacing and integrating techniques to disassemble and recombine in a different way disparate market frames. It is also vital in terms of giving the abstract conceptualisation of "Delivering a domestic market for Europe" a durability

and materiality that, as it starts to encroach on the material world around the initiative will result in changes and transformations to both.

Achieving durability by fitting black boxes together: economies of scale, network effects, and liquidity

Once in place, the SSE was no longer just a set of databases and algorithms running on very fast and powerful computers communicating through high-speed secure electronic data communications networks via a set of electronic messages with five existing legacy platforms and their databases. It is a key junction joining a number of large networks of transacting parties and objects of exchange, making possible their direct interaction and in the process realising significant network effects and economies of scale that help to reinforce its durability. The realisation of economies of scale and network effects made possible by the bridging of the separate market frames and networks by the SSE give the Euroclear initiative a durability that will come into play in trails of strength that will result when it comes into contact with other surrounding sociotechnical structures. In network analysis terms, the position the SSE fills would be described as a "structural hole" where, by making a small number of connections, many others are made possible (Hanneman 2001). In financial terms, it makes possible the linking together of five already large pools of liquidity into one single aggregate entity, something that in the world of financial markets is of great value and highly sought after[105].

A few numbers from the business case outlined in the "Delivering a domestic market for Europe" document make this point more clearly.

> "The merger of CRESTCo and Euroclear combines international and domestic markets to reach over 60% of the Eurotop 300 [equities], 52%

[105] According to Barron's "Dictionary of Finance and Investment Terms", liquidity is the "ability to buy or sell an asset quickly and in large volume without substantially affecting the asset's price" (Downes and Goodman 1998). The dictionary adds: "a high level of liquidity is a key characteristic of a good market for a security or a commodity" (Downes and Goodman 1998). Liquidity has become even more sought after as a result of the increasing demand for, and development of, complex financial instruments composed from a multitude of financial assets from different venues, countries, brokers, currencies etc. Hedge funds and other financial organisations that design and trade such instruments are always seeking out liquid markets in a bid to reduce their risks and improve their margins (Skinner 2007).

> of the domestic fixed income securities outstanding in Europe and, 62% of eurobonds held by the Common Depositories."

The ability to link all the pools of liquidity that existed around these securities in the previously discrete markets that the Euroclear initiative aims to integrate puts in place some very powerful network effects. Once these are in place, the durability of the relationships thus created increases substantially as liquidity tends to attracts more liquidity in financial markets. Once the five separate transaction volumes from the different marketplaces are channelled through the obligatory passage of the SSE, it becomes much more likely that the integration will hold together as the value of the resulting network increases substantially for all transacting parties as they are now able to transact many more objects with many more counterparties for significantly less cost and risk. Once these transactional flows start to pass through this single point, it becomes like the keystone in an arch: once in place and holding an entire structure together it becomes very difficult to remove it or change the structure it is holding together. Furthermore, as the network it is at the centre of expands and connects with other sociotechnical networks around it, this durability is reinforced further.

The entanglement of computational and political issues

Once the actual work on the integration of the disparate constituent settlement platforms was underway through the development of the SSE, the whole process of marketplace integration started to take-on a much clearer outline. New harmonisation needs started to be rendered explicit from the work involved in meeting the tangible needs of the actual first concrete part of the common marketplace being developed. This material expression of the initiative starts to makes explicit its needs from and consequences for the world around it. The Euroclear "Systems Consolidation" plan makes this point thus:

> "The precise path to delivery [of the Single Platform] depends on the outcome of harmonisation; the precise scope of later phases does not need to be, but also cannot realistically be, determined until this outcome is more clear."[106]

[106] (Euroclear 2003a, p.9)

At points where controversies arise, struggles – or trial of strength – ensue in which the durability of the entities that have come into contact with each other is tested. Out of these struggles it becomes apparent whether the design of the new entity will have to be altered to fit in with the world around it or whether the durability and obduracy it has managed to achieve so far is such that the world around it will be altered in such a way as to accommodate it.

In this initiative, this has been especially the case when the system being developed has needed to interface with external systems with their own inscriptions and prescriptions and logics. One such key point has been when the settlement system being developed has had to interface with the payment and banking systems in the jurisdictions it will operate in. Another has been the interfacing with the tax systems. All these points of contact have produced controversies that soon went beyond the ICT technicalities of the interfacing involved.

Withholding tax

One issue in which the interfacing between the emerging material expression of the cross-marketplace settlement system and the world around it became such a trial of strength out of which one or the other had to change in order for an accommodation to be achieved relates to the arrangements for withholding tax in France.

The chairman of the UK market advisory committee (UK-MAC) and member of the cross-market advisory committee (XMAC) described this issue as follows:

> "I don't know if this is a good example or not, but one of the most controversial ones was French withholding tax. Under French law, you must have a fiscal agent who is responsible for collecting resulting tax before payments are made to investors. ... It had the effect of requiring every remote user of the French market to have to appoint a French-based competitor to do that fiscal agent job for them and they said: "This is not a [level] playing field, we don't want to do that. You French have got to change the law so that a remote user can be free of having to use a competitor as a fiscal agent". The French marketplace said: "we completely understand that". We know they said this and we think they meant it. It did mean, of course, they were giving away a market

> advantage because that market distortion gave them income. But they did buy into the whole project sufficiently to realise that we've got to do this. So, they lobbied the French authorities to change French law. We, the non-French participants of all this, said: "we don't have confidence in you ability to deliver that. It is not a question of whether you are trying hard enough or not. We want a fallback that will deliver the same results and that got designed". And we all said: "Yes, lets do that and we will go for the fallback if you don't deliver". The French have very recently announced their firm intention of changing the law to deliver the [changes]. And here is the fine print, which seems, at first glance to completely undo the whole purpose of the change to the law. So, there is a lot to play for, but this is an example of where the French agreed to make legislative change and other change in order to accommodate a proper cross-frontier model."

A first solution proposed was for the issuer of the securities in the French marketplace to be allowed to account for withholding tax on distributions made to remote account holders. Although the model was seen as "technically workable", it was said not to be "straightforward for paying agents to implement". In addition, remote (non-French) system participants also "expressed reservations with some of this model's features".

In another solution proposed, Euroclear France would account for withholding tax on distributions made to remote account holders and this quickly became the preferred option[107].

Eventually, however, the French tax authorities submited "a high level proposal to the Finance Minister to amend the French Income Tax Code" in a way that would allow "non-French account holders of Euroclear France to act as French withholding agents with respect to income on French securities held in Euroclear France".

If approved, the intention of the French government is "to include the necessary changes in the draft Finance Law 2007 which will be adopted by the end of [2006] and become effective on 1 January 2007".

---

[107] Even these two fallback solutions, however, were far from straightforward, depending on some significant changes to French marketplace practices such as changes to record dates and ex dates. The French market, nonetheless, agreed to implement "a two-day gap between the ex date and the record date by 2007, to the extent required to resolve the French withholding tax issue".

The main points of the French government proposal are as follows:

- In order to be allowed to act as a withholding agent, the non-French financial institution would first need to enter into an agreement with the French tax authorities to take on the new role of "remote account holders".
- Non-French financial institutions that have entered into such an agreement would be allowed to deduct and remit French withholding taxes on income from French securities held with Euroclear France in lieu of the French issuers and paying agents. This would be on the basis of a mandate from that issuer or paying agent. In line with this mandate, the "remote account holder" would comply with all the withholding and reporting obligations of a French withholding agent. However, from a legal point of view, the issuers or paying agent who mandate the remote account holder remain the sole withholding agent liable to the tax authorities for the correct application of the withholding tax.

To carry out this role, the "remote account holders", would have to:

- Be legal entities that are established in an EU Member State or in a State that is part of the European Economic Area, having signed a convention with France to combat tax evasion
- Enter into a "model" agreement with the French tax authorities, which outlines their reporting and withholding obligations as a remote account holder/ remote withholding agent
- Be mandated by the last French intermediary in the payment chain to deduct withholding tax, by signing a "mandate agreement".

According to Euroclear, "the French issuer (ANSA, 'Groupe titres') and the French paying agent (AFTI, 'Groupe Emetteurs') communities have already expressed their support for this new approach", and a working group has "begun drafting the model mandate agreement, which will be submitted for

consultation to foreign institutions"[108]. This working group was also "focusing on finding a technical solution to alleviate the administrative burden associated with having to sign individual mandate agreements".

On their side, the French tax authorities were also preparing "the model agreement, which foreign account holders will have to enter into with the French tax authorities in close consultation with all stakeholders, including foreign financial institutions".

The first draft was expected to be available "by the end of January 2007". This draft would cover, amongst other issues, most of the obligations of a remote withholding agent, including:

- Documentation and reporting requirements
- Withholding and deposit obligations
- Audit requirements
- Penalties
- Events of default

While many of the practical details of the proposal based on a change in law still remain to be worked out, Euroclear "feel confident that through consultation with foreign institutions on the mandate, the standard agreement with the French tax authorities, and any other practical arrangements, the law change will lead to a satisfactory solution for all", that would ensure "a level playing field between foreign and French account holders in Euroclear France".

Cross-central bank payments

The point of interface between the emerging cross-border securities settlement system and the emerging pan-European monetary and payments systems, is even more explicit and illustrative of the entanglement of computational and

[108] ANSA is the French securities issuers' association, or "Association Nationale des Sociétés par Actions. AFTI is the French Association of Securities Professionals (Association Française des Professionnels des Titres), which represents participants in the 'post-trade' sector of the securities industry in the French marketplace and within the European Union.

political issues involved in the reconfiguring of the architecture of exchange involved in the integration of five separate securities marketplaces across jurisdictions.

This interface has become a centre of actions, questions and responses on the part of a range of agencies that have been compelled to respond to the 'fact' of the SSE and its interfacing requirements with a number of central banks participating in the Eurozone inter-central bank payment system.

At the centre of this controversy are different models for the payment mechanisms that link the settlement system with the central banks and their payment systems. Most such mechanisms can be fitted, more or less, into two broad categories:

- The 'interfaced model' in which there is a separation of the securities settlement system operated by the CSD and the payments system operated by the central bank. This requires coordination between the two system operators in order to provide DvP, as the cash records are operated exclusively by the payment systems of the relevant central banks.
- The 'integrated model' where the processing of both securities book entries and cash book entries takes place in the securities settlement system. This requires legal arrangements between the CSD and the central bank to ensure that finality of payment can be achieved within the CSD.

Because, according to Euroclear, the 'interfaced model' requires "managing dependencies on several external systems (e.g. central bank payment systems), which creates delays and additional risks in a cross-border environment", in order to establish links between central banks, the SSE has been designed on the basis of the 'integrated model'. One of those involved in the design and development of the SSE and Single Platform explains the choice as follows:

> "With the Banque de France system liquidity gets shoved over to the settlement system at the start of the day and settlement goes on, debits and credits, the account is actually outsourced to the settlement system. Then, two or three times a day, the result is posted back to the Banque de France so liquidity can be made available for other systems. ... The integrated model has the whole of the [central bank cash] account processed at the securities settlement system. So we looked at these two methods and we liked the Banque de France model more because it was more efficient. You have far less messaging between the central bank and the securities settlement system, therefore less can go wrong. You have the liquidity where you need it, which is on the [securities settlement system]. It is chundering through 600,000 transactions a day, market-wide, so that is where you need the information from the central bank. ... We were going to have to pick one of these models to harmonise on, and again, there was no real – apart from pure cost and efficiency issues – desperate need to harmonise. The harmonisation would give us this cheaper and less complicated consolidation, so it was beneficial to harmonise. [On the technical level] TARGET2 said: "if you want to push liquidity to TARGET2, this is the message you have to use and if you want to get liquidity out of TARGET2 this is the message to use". So those pure mechanics are used in both cases. So the interface model you send liquidity on a regular basis and get a reply back using these messages or with the integrated models you send one at the start of the day and you get 2 or 3 sweeps during the course of the day. So the actual message used to interface to TARGET2 is the same in both cases. It is only how you use those messages in terms of the business process."[109]

This apparently technical decision has been at the centre of an expanding controversy between Euroclear and the European Central Bank that is in charge of TARGET, the existing Eurozone inter-central bank payment system that is soon to be replaced by TARGET2, a new and more centralised inter-central bank payment system for the Eurozone.

A report from the cross-market market advisory committee, the XMAC, from November 2005 described the situation at the time as follows:

> "The [committee] received an update on discussions with [the] central banks on the integrated model. The decision of the ... Governing Council of the European Central Bank (ECB) on whether to accept the model has again been deferred. Whilst it is known that some central banks [in the rest of the Eurozone] do not favour the proposed model, informal discussions have nonetheless been taking place at Governing Council level. A senior-level working group, comprised of payment systems' senior figures, has been formed to consider the way forward. The prolonged uncertainty about the future of the integrated model is unhelpful but Euroclear has no option but to continue, considering that

[109] (Interview C 2006)

> the proposed model is within the scope of existing ECB policy and Euroclear has already undertaken two years of development based on this published policy position. The Harmonisation team continues to meet with European central banks to address any issues, concerns or misconceptions that they might have about the integrated model."[110]

The same interviewee who described the design decision to opt for the integrated payments mechanism for the SSE, said about the friction with the ECB:

> "The real issue, because at the end of the day TARGET2 is just about messages and functions to move liquidity from A to B, was really about how to use that liquidity once it has been moved from A to B. So we had two models and this really was one of the pivotal points of discussion during the whole of the Single Platform and may well have been one of the contributing factors to the whole TARGET2-Securities proposal. ... So we thought we would go for the integrated model because that was more efficient. That created a lot of ructions in the ECB where they essentially didn't agree with us that the integrated model was the most efficient way and that began all the stuff that I am not going to go into."[111]

The controversy eventually became a full-scale trial of strength between two competing versions of how to integrate settlement systems across different marketplaces and jurisdictions when the ECB announced on 7 July 2006 that it was "evaluating opportunities to provide settlement services for securities transactions"(European Central Bank 2006). The ECB announcement was as follows:

> "Conscious of the need for further integration in market infrastructures, and extracting the benefits from the implementation of the TARGET2 payment system, the Eurosystem is evaluating opportunities to provide efficient settlement services for securities transactions in central bank money, leading to the processing of both securities and cash settlements on a single platform through common procedures. At its meeting on 6 July 2006, the Governing Council of the European Central Bank decided to further explore in cooperation with central securities depositories and other market participants, the setting up of a new service – which may be called TARGET2-Securities – for securities settlement in the euro area.
>
> The objective of this project is to allow the harmonised settlement of securities transactions in euro which are settled in central bank money. Synergies for the market with other facilities operated by the Eurosystem

[110] (Cross-border Market Advisory Committee 2005)
[111] (Interview C 2006)

> will be sought, in particular in connection with the future TARGET2 payment system.
>
> The implementation of such a facility, which would be fully owned and operated by the Eurosystem, would allow large cost savings as a result of the high level of technical harmonisation that this facility would entail for all market participants and would represent a major step towards a single Eurosystem interface with the market.
>
> The Eurosystem will now consult central securities depositories and other market participants on the envisaged facility. A final decision on this project is expected by early 2007."[112]

The stakes could hardly be higher. The development of TARGET2-Securities (T2S) would almost certainly mean that much of the investment into developing the Single Platform made by Euroclear would be rendered worthless. Not only the actuality but also even the potentiality of T2S is enough to increase the uncertainty of the investment to a degree that it would become unpalatable for many Euroclear members to back it.

Other controversies and trials

Another example of how apparently technical matters can get entangled with political, legal, and tax issues at the point when the new entity makes a concrete demand on the world around it was highlighted again by the chairman of the UK-MAC.

> "The Dutch have a field in their information exchange when they are *matching* transactions, which identifies the beneficial owner in the transaction, whereas in the UK we do not do that. You do not have the field. You do not have the box. The Dutch say they must have that [for legal reasons] and they also think it would give [one] better straight through processing because you know who [the transacting parties] are so if anything goes wrong, you know there is traceability and all that. The British, in particular, said: "this is hopeless because a lot of us have nominee accounts which are aggregated and have lots and lots of people in them. ... That has been resolved for the time being and it is one of the few where there has been real compromise. For Dutch securities traded on the Dutch stock exchange, regardless of where the trader is, that box will be filled and will have to be available for a trial period and we'll see how it goes. Anybody trading outside the Netherlands will not *have* to do this. You can do it optionally. Some people have the boxes and want to do it. Optionally, you can do it, but you don't *have* to."

[112] (European Central Bank 2006)

As the section in this chapter on the harmonisation involved in developing a cross-marketplace and cross-border settlement system shows, there are many areas which involve significant adjustments between the integrated settlement platform being developed and the world around it. The necessity of a response is created even if the response itself cannot be pre-determined (Barry 2002).

Some require extensive adjustments and changes and others can be dealt with through some kind of work-around. As they are overcome, one more entity is successfully attached to the new arrangement, contributing to its durability and strength. The example of the continuing controversy over the choice of integrated or interfaced model for the interaction with the central banks and the Eurozone payment system that has spread out from a question of technical interfacing to a much broader debate about the terms of European financial integration and the roles in this process for a number of actants illustrates how such issues can escalate in a dramatic way, dragging in many more entities and resulting in a massive trial of strength between two different visions of how financial marketplace integration should proceed and where the very survival of one or the other approach is likely to be threatened according to the outcome.

Discussion/Analysis

ICT integration or sociotechnical articulation?

Introduction

In all the five marketplaces that the Euroclear initiative aims to integrate, a specific exchange architecture for securities transactions formats the calculative encounters of the market participants and is inscribed into their respective settlement platforms. Each separate legacy settlement system provides a setting within which specific roles are assigned to the human and material entities included in it and that frames the interactions of these entities. A set of interrelations is thus stabilised, both among these entities and between them and the world outside. The challenge for the designers of the integrated system is to fit these separate frames together into a new and durable configuration.

Pre-inscriptions

In the age of paper securities certificates, market frames were made durable through the application of the relevant legislation governing the definition and transfer of titles to property such as securities, the following of formal and informal rules, processes, practices, and customs and the constrictions of the material arrangements that accompanied them. With the introduction of electronic ICTs, many of these elements were inscribed into electronic ICT-based platforms. Apart from the technical work of writing computer programmes, designing electronic databases, linking these through the exchange of electronic messages over electronic data communications networks, this process of inscription also involved amendments and changes to the laws and regulations governing the definition and transfer of such titles as well as the roles and practices of market participants. The roles, procedures, and interrelations found in the previous frames were standardised and coded into an electronic ICT-based system and in the process made much more explicit and unambiguous. Like a casting list for a film or theatrical

performance, it was now possible to look at the manual for the settlement platform and read-off it the roles and competencies allocated to the various human and material entities involved in securities transactions. Not only could transactions be processed much faster, at much bigger volumes and lower costs, but the framing of the market was also rendered clearer and more explicit.

The introduction of ICTs to securities settlement at the level of the individual constituent marketplaces also brought with it an inscription into these platforms of an emerging body of formal knowledge relating to the assessment and management of risk in the settlement activities of financial marketplaces and the importance of settlement arrangements to the efficiency of these markets from bodies such as the Bank of International Settlements, the Group of 30, the Giovannini Group, and others (Group of Thirty 1988, 1990b, 1990a, Committee on Payment and Settlement Systems 1992, 1995, 2000, 2001, Committee on Payment and Settlement Systems and Technical Committee of the International Organization of Securities Commissions 2001, Giovannini Group 2001, Guadamillas and Keppler 2001, Giovannini Group 2003, Group of Thirty 2003, European Commission 2004). As a result, a more general conceptualisation and framing of securities market settlement activities was staring to take shape. Different classifications of settlement systems were being developed based on the collection of comparative data on different settlement systems, the listing of common functions and features as well as different ways of doing things, the compilation of tables comparing their relative merits, and discussions regarding this relative merits and conclusions proposing archetype models of settlement systems[113].

Rendering marketplace integration calculable

The tighter framing of securities transactions resulting from this introduction of ICTs rendered more explicit the dimensions of previously fuzzy and nefarious questions regarding the integration of financial marketplaces that until then had

[113] See (Committee on Payment and Settlement Systems 1992, 1995, 2000, 2001, Committee on Payment and Settlement Systems and Technical Committee of the International Organization of Securities Commissions 2001, Giovannini Group 2001, Guadamillas and Keppler 2001, Giovannini Group 2003, Group of Thirty 2003, European Commission 2004)

been the domain of economists and other experts and industry visionaries in abstract debates about economies of scale, network effects, market efficiency, systemic and other risks, welfare maximisation etc.

The links and relations that had to be established for the separate market frames represented by the different settlement systems to be integrated now became much more visible. They could be read off the documentation for each platform, listed side-by-side in a separate common document that can be circulated among the technical and other experts involved in the design and operation of the platforms. Meetings could be held at which ways of building these links could be discussed and working groups charged with developing them. Lawyers could be asked for their opinions on how particular solutions would interface with the legal frameworks that are inscribed into the platforms and executives can more clearly judge the costs and benefits of such an initiative(Interview F 2006). Now the space, time, and cost reducing properties of ICTs could come into play and be judged, not on their own as a priori assumptions, but in combination with all these other elements that this merging of sociotechnical arrangements or frames involves.

From corporate integration to ICT platform integration

Motivated by high-level visions of an integrated market for securities formed out of diverse elements such as, concepts of economies of scale, network effects, market efficiencies, the emergence of a formal body of knowledge, reports and recommendations from bodies such as the Group of 30, Bank of International Settlements, the Giovannini Group, the European Commission and others, and the integration potential of ICTs, the Euroclear plan for the establishment of a cross-marketplace settlement system started to take shape (CRESTCo 2002b, Euroclear 2002, Interview F 2006).

The first step envisaged the development of a single corporate entity out of mergers with the entities operating the individual settlement systems for individual marketplaces. This would then be followed by the gradual development of a common ICT-based settlement platform that would be used by all the merged entities in their particular marketplaces. The aim was for

significant economies of scale in terms of shared platform development and operating costs to be realised, but also make possible the necessary exchange architecture re-configuration and standardisation so that the transfer of legal title to securities across marketplaces and borders could be effected. This would, in effect, bring about the establishment of a common cross-border marketplace for securities that retained all the property rights inscribed in them in their existing jurisdictions of origin, resulting, in turn, in increased network effects and a bigger and deeper pool of liquidity. A much bigger circuit around which unambiguously framed and legally binding relationships between participating lenders and borrowers can move is established.

The work of articulation

In its earliest steps, the design and development of the new system has involved the articulation of economic concepts, emerging bodies of expert knowledge, corporate entities, and ICTs [114]. This work of conceptual articulation was particularly evident in the "*Delivering a Domestic Market for Europe*" document published by Euroclear following the successful merger with CRESTCo which can be seen as the high-level blueprint for the single settlement platform (Euroclear 2002). As this plan unfolded, there was a continuous movement towards a more durable configuration of the elements being brought together and assembled in it and this is the real meaning of notion of articulation.

The strategy of the Euroclear Single Platform designers in this process of articulation was to use a process of corporate and ICT integration as the starting point for a broader process of market change and reconfiguration. With a single corporate entity in place, it would be possible to have the kind of control necessary for the successful integration and standardisation of ICTs and processes internal to the settlement system operators.

The central calculation behind the development of the Single Settlement Engine (SSE) was that starting with the core settlement function of delivery

[114] Another use of this notion of 'articulation' in a financial markets setting is provided by Lepinay in a case study of a trading room (Lepinay 2007).

versus payment (DvP) were the most common ground and least local differences among the platforms of the merged entities existed, further harmonisation, standardisation, and integration would be push outwards to include the more localised and specific aspects of the settlement systems and local marketplaces being integrated. This would include a common single interface, common secure communications network, standardisation of back-office arrangements for all users across marketplaces and eventually the establishment of common business processes and practices, resulting in a single marketplace for securities issued in the UK, Ireland, France, Belgium, the Netherlands, and Euroclear Bank, regardless of whether the local stock exchanges had merged or remained separate entities.

The approach of the system developers is reminiscent of Latour's position in "Science in Action" regarding internal/external boundaries in science and technology settings:

> "... the internal/external division becomes the provisional outcome of an inverse relationship between the 'outside' recruitment of interests – the sociogram – and the 'inside' recruitment of new allies – the technogram. With each step along the path, the constitution of what is 'inside' and what is 'outside' alters."[115]

Implicit in the strategy of the developers were a number of assumptions:

- So-called 'soft' elements such as practices, institutions, legislation, ways of doing things are 'harder' and more difficult to transform and reconfigure than ICTs in such a setting.
- Settlement systems are at the intersection of many sociotechnical networks and, as a result, are very difficult to alter as all adjacent networks also have to be accommodated in some way.
- ICTs start off as malleable and configurable and can be used to re-wire the relationships and linkages that constitute an exchange architecture, but, like a keystone in an arch, they become hardened once successfully articulated with other elements such as existing market structures,

[115] In (Latour 1987, p.159)

institutions, legislation and regulation, practices, status hierarchies, customs, cultures, and ways of doing things.

The front line between the 'inside' and 'outside' of the unfolding system

The boundary between the 'inside' and 'outside' of the unfolding system proved to be a key strategic location for the Euroclear developers. It has been a central strategy of theirs to tightly control the boundary and interaction between the technical parts of the system and the market participants. As the core of the system started to take shape in the form of the SSE, the system developers sought to tightly control the outer boundary of that black or grey box while the re-wiring work took place 'inside'. The only doorway between what was happening on the 'inside' and 'outside' was through their documentation, consultation processes, and training programmes until actual interfacing between the unfolding platform and the market participants and their systems takes place. All these elements, including even the consultation process with the market participants and the workshops, have been an integral part of the development of the system. What is going on inside the SSE is described by the designers as "technical", an improvement that leads to greater efficiency and reduced risks, something internal that will not change the experience of the users who will still experience the system as they did in the previous local setting (e.g. CREST in the UK) (Euroclear 2006b). The central strategy for ensuring that the 'black box' remains, if not completely closed, at least obscure during this design phase, is by ensuring that the interface with the system and its levels of performance remain, in the eyes of the local market participants, as "unchanged" as possible.

Despite all the efforts to hold the line and mediate the experience and understanding of the 'inside' of the new system of those on the 'outside' via tightly controlling access to the 'inside', the boundary in practice proved more porous than anticipated. Controversies, despite the best efforts of the designers, leaked out and overflowed. The boundary between the 'inside' and 'outside' of the new system being developed was a constant struggle and as it moved outwards, more and more intersecting networks and the scripts that are

inscribed in them had to be incorporated and articulated into the system before it could attain the durability it needed.

As the new proposed arrangement for cross-border settlement has moved from the conceptual model outlined in the "Delivering a Domestic Market for Europe" document (Euroclear 2002) towards the material reality of the Single Platform via the SSE, more external scripts that are encountered in the process of articulation have to either be somehow accommodated or by-passed or. As the settlement system designers and developers move outwards from the core electronic and algorithmic heart of the platform towards the wider marketplace, they have less and less direct control over the entities that have to be incorporated. The scripts into which they have to be enrolled get more and more complex and complicated, linking-up more and more entities. For example, connecting up the central settlement processor to a national operator register in which title to the ownership of the securities is recorded and through which legal ownership of the securities is conferred, has many fewer variables and less of a proliferation of actant connections than getting a new graphic user interface (GUI) or electronic messaging technology adopted across the entire marketplace by all users.

Even the process of articulating the simplest of ICT elements involves work both to ensure the trouble-free exchange of data between components, but also the fitting together of the broader scripts and assumptions built into them – however small and non-complex these may be. It is at that moment of connecting-up that any mismatch or misalignment becomes obvious or explicit, for the simple reason that the linking does not work (like putting a disk from a Mac into a PC). At the lower level, because of the limited complexity of the scripts involved and the smaller number of entities they have to hold together, the controversy generated from a potential conflict of scripts is usually limited and with a relatively small reach that can be resolved among the technicians and engineers. As the inside/outside boundary move outwards, however, the connectivity of the elements to be fitted together increases. They get more and more complex, linking more and more actants and because of this, if a mismatch occurs, the controversy generated spreads out and links-up many

more actants and scripts and subscripts, some of which may have only come into existence as a response to the ongoing re-articulation initiative involved in the building of the new system. It is only when such a conflict of scripts arises out of an effort to connect-up actants and the resulting controversy propagates and links-up all those with a stake in it that the extent and composition of the conflicting scripts becomes visible and explicit. It is then up to the designers/developers to try and find a way to manage these and resolve them. Because they were not visible/explicit until then – possibly also not yet in existence – it is not easy for the designer/developer to know them all in advance and design the system to take account of them. Inevitably there will always be an element of real-time and real world experiment to this work.

One example from the evidence collected that helps to illustrate this point is a small design controversy that had to be resolved regarding the inclusion or not in the Euroclear SSE of an investor ID field. This started as what initially looked like a minor technical issue: the obligatory use of an investor ID and presence of an ID field in the Dutch settlement system's database. Soon it became apparent or explicit that this is due to Dutch law and it was no longer a clearly technical issue. It linked-in directly to the Dutch legal system, but also broader fundamental questions of taxation, property ownership, the relationship of the individual to the State, anonymity, transparency, personal data protection and so on. The small technical issue of the presence or absence of simple data field in the common securities accounts database got linked to fundamental constitutional issues about the confidentiality of the banking system, or more pragmatic issues relating to the availability of 'bearer' share certificates (France) or the extensive use by investors of nominee accounts in the UK (i.e. share trading accounts where, while the investor is the 'beneficiary' in terms of being entitled to the value of the shares if they are sold, any dividends they may pay etc, he or she is not the ultimate legal owner of a particular share with all the legal entitlements this carries). The designers then have to decide whether it is easier to change the political, legal, or even constitutional reasons behind this initially small technical question or come up with some technical workaround that not only solves the problem, but is also acceptable within all the jurisdictions that the system will need to operate in. Even at the technical

level however, the question was no longer so small, because a field could not exist in only one of the national databases because the logical structure of the electronic messages that would link the various parts of the system together did not allow it, or made it very problematic. They either all had to have it or no one. While on the common platform of the SSE this was worked-out by including the investor ID field, but allowing for it to have a "0" (zero) value (not empty or void or null), this meant that all the other legacy local systems (UK, France, Belgium) that in the first phase of the SP would still act as the local interface into the SSE, would have to do all the necessary updating work on their old systems, which they will soon no longer have any use for, in order to include a new Investor ID field in the system that would be set to zero.

Despite the best efforts of the designers in their business plans and blueprints, it is through the process of ICT platform integration itself that many less visible aspects of the market frames and exchange architectures inscribed into the individual local settlement platforms emerge and become explicit. The computational and legal certainty that settlement systems require means that any ambiguity – even the most minute – has to be resolved at every stage of the articulation process before the new settlement system can hold together. A computer cannot stop in the middle of a settlement algorithm to ask for clarification from the legal department for a certain problematic transaction, an unpredictable behaviour from a particular market participant, or an unexpected type of transaction or form of data. All these have to be resolved and designed into the platform before it goes live. All issues of jurisdiction, property rights, obligations and so on have to have been resolved in advance. What initially might have looked like a neat and well-defined ICT platform integration exercise is much more than that. It is a fully-fledged marketplace re-framing exercise that generates what Callon refers to as "hot situations" and "hybrid forums" (Callon 1998b, p.260)[116].

[116] These result when there is an absence of a stabilised knowledge base and a presence of a wide variety of actants, the list and identities of which are unstable and fluctuate in the course of a controversy and with different and often mutually incompatible descriptions of future world states being put forward (Callon 1998b, p.260).

The skill of the designers is to, bit-by-bit, step-by-step, articulation-by-articulation, cool such 'hot situations' and stem overflowings so that the boundary of the new frame where entry and exit points are controlled and managed – and thus made predictable – is gradually pushed outwards to encompass more and more actants. This process of articulation and interfacing is anything but easy and straightforward. Every new step risks triggering a new and unpredictable 'hot situation', especially as the boundary moves from the algorithmic core of the Single Settlement Engine towards entities outside the direct corporate or operational control of Euroclear.

Sociotechnical engineers

With the process of pushing the boundaries of the new marketplace outwards fraught with difficulties and perils associated with unforeseen and potentially far-reaching overflowings, how do those charged with bringing about this re-framing cope with the situation?

The designers and developers of the Euroclear Single Platform consciously saw their work as designing or adapting both the human and technical elements to be incorporated into the system. It is as much social as ICT engineering. They are re-interpreting institutions, re-shaping the roles of the marketplace participants and the business and ICT practices they have in place as well as designing and developing new settlement algorithms, installing new computer hardware, and writing new sets of electronic messages and databases.

It is not enough to develop a working ICT platform for the marketplace reconfiguration implicit in the development of the new settlement system to be successful. Functionally the ICT parts of the settlement platform may work perfectly, but if all the other non-technical elements of the ensemble are not in place and working seamlessly with the ICT platform, the platform itself can fail, such as, for example, becoming obsolete or being abandoned before it gets to be used in a meaningful way. As the intervention of the ECB has shown, even the possibility of a rival platform some time in the future may threaten the feasibility of the Euroclear initiative because the conceptualisation of the system and many of the key business, economic, political, and institutional

assumptions that are explicitly or implicitly inscribed in it – or are to be inscribed into it – no longer hold.

The detailed articulation work carried out by the Euroclear designers shows that it is through the interactions and mutual shaping of human and non-human entities accompanying the market reconfiguration processes and the translations, enrolments, settlement, and trials through which the various actants are eventually accommodated, that the final outcome of a functioning cross-marketplace securities settlement platform that makes possible the cross-jurisdictional transfer of legal title to securities is arrived at. It is by finding ways to successfully fit and hold together both the social and ICT elements involved that the new single securities marketplace will become a reality, and it is due to the complexity and risks, many of which are not visible before the development of the new system is underway, that such financial marketplace integration has been the exception rather than the rule.

Conclusion

The designers and developers of the Euroclear Single Platform cannot just be IT experts. Settlement systems, but also marketplaces, are assemblies of human and non-human elements. The work of the designers and developers is to be the assemblers of such sociotechnical arrangements.

This research shows the explicit strategy on the side of the developers to design both the technical and human aspects of the marketplace being developed by fitting together a number of heterogeneous components. From the design of the settlement algorithm that positions the necessary assets (securities and payments) and sequences the transactions, to the linkages with the settlement banks, the payment system, the brokers, registrars etc, the work of the designers and developers has been to connect-up all these elements in such a way that they work together and the data flows from them all the way down to the algorithm processor at the heart of the new platform.

All these components to be linked-up are all smaller or larger assemblages of human and material elements, even the algorithms and the movement of

electrons in the computer circuitry[117]. All have scripts of varying complexity inscribed in them that organise the relations among their constituent elements but also format how these assemblies interact with the world around them. Many will have already become durable 'black boxes' through previous processes of inscriptions and trials. Every new connection and interface established successfully will also have to overcome such trials.

If the nascent Eurolear settlement system manages to survive and becomes the de facto, and possibly de jure, system for securities settlement in part of Europe, the views and assumptions about markets, ICTs, and the roles for market participants that are inscribed in it will have prevailed and will become increasingly 'black-boxed' and taken for granted. If not, a new round of translations, enrolements, accommodations and settlements will have to be entered into.

Whatever the outcome, the interfaceability and configurability of ICTs will, nonetheless, have acted as a stimulus for market reconfiguration. Once the process of marketplace integration enabled by ICTs has been set in motion, however, it is much more difficult to anticipate the outcomes. ICTs and the increased configurability they appear to offer make it alluring to imagine that market frames can be easily joined-up through ICT systems integration. Existing marketplace configurations, however, do not just disappear or dissolve into thin air. They are inscribed to a greater or smaller extent and in a more or less explicit manner in apparently technical components to be assembled together. It is as these apparently technological components are articulated together that the inscriptions become explicit. This inevitably results in controversies and contests being spawned and new settlements being required that may not have even been anticipated in the design process.

[117] For a brief but compelling historical account of the different ways electrons were understood and conceptualised and articulated with different notions of mass, time, and space in the early 20th century, see (Galison 1999).

From concept to stubborn fact

Introduction

The process of ICT-enabled marketplace integration opens up many areas of contestability and, as the research found, it is a key concern of the designers to try and limit the reach and scope of these contests and controversies and maintain a controlled front-line among the inside of the system they control and the outside they do not, while gradually pushing outwards the boundary to include ever-increasing areas of marketplace activity. As new connections are put in place and new relations among entities are established, the participation of the assembled entities in a wider set of relations is also rendered more explicit. The encounters thus generated can reveal features of relations not previously taken into account or which resist the enrolment proposed in the script of the designers or the script of the designers may encounter a competing script. When such a situation arises a trial of strength will ensue through which the durability of the assemblages the competing scripts bring together is put to the test. In the process both the strength and configuration of the connections of the competing assemblages is rendered explicit. As if part of a real-time experiment, elements and links of the competing assemblages that were previously obscure or not considered central are revealed and brought centre-stage. In practical terms this can result in an exercise in tracing the assembling of sociotechnical collectives providing as much insight about the world within which the assemblage must exist as about its own development.

Studying the technically inspired process of marketplace integration set in motion by the Euroclear initiative it soon became obvious that there were also structures, geopolitical situations, market status hierarchies and so on that could not be ignored and that ultimately frame, constrain, or even induce or provoke what is being attempted. Not just there, ready to have an effect on the word and which innovation initiatives just bump into. Through their contact with such innovations, trials ensue that put these structures to the test and render them and their inscriptions explicit and thus contestable. This does not mean that there were simply present but implicit. It means that they lacked a

concrete expression until they were linked with the material reality and demands of an actual system[118].

The material arrangements being put in place for the settlement of cross-marketplace and cross-jurisdictional securities transactions become a concrete interrogation of the world – both conceptual and material – surrounding the initiative. Points of interface between the emerging securities settlement system and other sociotechnical systems and networks become a nexus of actions, questions and responses on the part of a range of agencies required to respond to the concrete demands and implications of the needs of the new system to interface with the world around it. The emerging material fact, rather than abstract plan, of a functioning cross-border settlement system demands responses, yet the course of the responses, both on the part of the designers of the settlement system and the other external entities this interfacing has brought the system into contact with, cannot always be predicted (Barry 2002).

The TARGET2-Securities trial of durability

One such example in this research has been the proposal of the ECB to develop its own pan-European settlement system under the name of TARGET2-Securities (T2S) that has the potential to render the Euroclear initiative obsolete.

The core function of any securities settlement system is to make possible the problem-free, incontestable, and final transfer of legal title to securities among transacting parties, usually in exchange for a pre-agreed payment. This means that the interface between settlement systems and payment systems is a crucial one. It also means that sometimes the distinction between the two systems can lack clear contours.

In the proposed Euroclear cross-marketplace settlement system the payment mechanism is built around relations between the transacting parties, their

[118] For example, everybody might know there is a certain law or regulation, but nobody can anticipate what this law "does" in a specific case unless something triggers this specific case which is to be made explicit in some very contestable manner.

settlement banks, and the national central banks at which the settlement banks or the settlement system participants themselves have cash accounts.

While the specifics can vary, in a single jurisdiction settlement system all system members will have a securities account and a cash account. In the UK and France they will also have a settlement bank (known as *compensateur* in the French system) mandated to provide the necessary credit for their settlement activities[119]. The settlement banks provide a debit cap for each of their settlement system clients and before any payment is made from a member's cash account, the settlement platform checks to make sure the cap is not breached. During the business day members' cash accounts are credited with receipts and debited with outgoing payments. At the end of each business day any outstanding negative balance is paid by the settlement system participant to the settlement bank while any outstanding credit is paid by the settlement bank to the settlement system participant and the balance is set to zero for the next business day. In order to ensure that the settlement system is not disrupted due to lack of cash, the funds made available by the settlement banks at the central bank for the settlement activities of their clients and totalling the sum of the debit caps for all their settlement system clients, must be available to the settlement platform throughout the business day. How this is arranged in practice can have important implications for the functioning of both the settlement system, but also the banking and monetary systems and because of the credit extended by the settlement banks to their settlement system clients, this interface can be seen as a potential cross-over point into the banking and monetary systems for risks generated in financial markets.

It was regarding the arrangement of this exact interface between the proposed new cross-market and cross-jurisdiction settlement system and the newly established TARGET2 inter-central bank payment system for the Eurozone developed by the European Central Bank (ECB) that the first important trial of durability for the new system takes place. It is through the unfolding of this trial that many of the less visible contours of the front-line between the

[119] Participants in the Belgian CIK system and Euroclear Nederland have their own central bank account.

unfolding system and the world around it are render explicit and the implication of the new system in broader politico-economic controversies becomes observable.

The starting point of the controversy was the type of interface to be used by the proposed Euroclear platform to link into the TARGET2 inter-central bank payment system. Again, although the specifics can vary, links between a payment and settlement system can be divided into two categories: interfaced and integrated.

Broadly speaking the two linkages can be described as follows:

- With the "interfaced model" there is a complete separation of the securities settlement system operated by the CSD and the payments system operated by the central bank. This requires coordination between the two system operators in order to provide DvP, as the cash records are exclusively in the payment system of the central bank.

- In the "integrated model" the processing of both securities and cash accounts takes place in the securities settlement system, although there are different ways of achieving this. One way, as is the case with the UK CREST system, is for the necessary legal arrangements to be put in place between the CSD and the central bank to ensure that finality of payment can be achieved within the CSD. Another way to achieve this is for the actual cash set aside for settlement activities to be transferred to the CSD for the duration of the business day and then returned to the central bank at the end of the day.

Citing the management of dependencies on several external central bank payment systems and the delays and additional risks these can generate in a cross-border environment, the Euroclear designers decided against the "interfaced model" and opted for the latter version of the "integrated model" (Euroclear 2004c, pp.32-33Interview C 2006, Interview E 2006).

Having a not insignificant proportion of reserves exiting the Euro monetary system to support the "user-owned and user-operated" Euroclear settlement system appeared to be a key sticking point with the ECB, as interviews with the Euroclear developers (Interview C 2006), a member of the Cross-border Market Advisory Committee (Interview E 2006) and the following passage from a speech by Jean-Michel Godeffroy, Director General Payment Systems and Market Infrastructure at the ECB indicate:

> "... the most efficient model is the integrated model, where cash and securities are settled in the same platform. Consequently, there were two options: outsourcing the management of central bank accounts to the CSDs, as in the system which Euroclear will open soon, or outsourcing the CSD accounts to a central bank platform. The conundrum is simple. Outsourcing cash accounts to the CSDs means fragmentation of liquidity. Outsourcing securities accounts to the Eurosystem means integration and economies of scale. To be complete, I should add that the Eurosystem has a clear preference for keeping full control of its cash accounts. A central bank is 'central' because it holds the accounts of the banks in its country. In particular in times of crisis, central banks prefer to keep full control of their accounts."[120]

The upshot of this controversy was the proposal by the ECB to develop its own TARGET2-Securities pan-Eurozone securities settlement system that would be an internal part of the TARGET2 payments system, with the CSDs in effect outsourcing the updating of their securities accounts to the ECB system where the cash accounts of the settlement system participants would be held.

Two clear alternatives for the cross-market and cross-jurisdictional settlement of securities transactions were thus brought into being and in competition with one another embodying very different philosophies about: the demarcation between securities settlement and payment systems; the conceptualisations and relative importance of the risks these systems face; who should run them and how and in whose interest; who's money it is that flows through these systems; the relationship between such systems and wider reconfigurations of financial markets; the implications of these choices in the wider power struggles for primacy among the calculative agencies that comprise global markets and the

[120] See (Godeffroy 2006)

states with which these competing calculative agencies have somehow managed to forge alliances with.

The stakes could hardly be higher. The development of T2S would almost certainly mean that much of the investment into developing the Single Platform made by Euroclear would be rendered worthless. Not only the actuality but also even the potentiality of T2S is enough to increase the uncertainty of the investment to a degree that it would become unpalatable for many Euroclear members to back it. As the trial of strength between the two assemblages unfolds, however, the balance starts to shift to the other side. The Euroclear platform has established "facts on the ground". It has a corporate and governance structure that reflects the use made by the system participants. Thus, despite their divergent and often competing interests, they have a common interest in backing this platform. They will have a share of the returns it makes and a say in how it is run and what investments are made in the future. The extensive and open marketplace consultation undertaken by the Euroclear designers and developers has not only provided some further comfort to participants that their interests and needs are being taken into account, but also provided the Euroclear designers and developers with a degree of know-how and grass-roots knowledge that has been invaluable in building an apparently robust business case for the project. Furthermore, through the actual development work they have already done and the actual material outputs they have already produced, they have gained a unique experience regarding the practical difficulties that any initiative such as the one proposed by the ECB would face. This has then helped them highlight with more effectiveness the weaknesses of the ECB proposal. Above all, however, thanks to the putting in place of the Single Settlement Engine that, through a common settlement processor, has linked materially the settlement platforms of the individual constituent marketplaces, they have inscribed most of the relations crucial to the success of their initiative into a well-defined and functioning material object that is not far from the status of a so-called black-box. The durability imparted by this black box to the Euroclear assemblage is further amplified by the substantial network effects it brings about by linking-up the liquidities of

five separate marketplaces and making possible substantial economies of scale and scope.

Even as the balance appears to be tipping back towards the Euroclear proposal, however, there remains a potentially very powerful weapon on the side of the ECB. Access to the TARGET2 central bank payment system, operated and controlled by the ECB, is a key dependency for the proposed Euroclear system. Without access to central bank money, the Euroclear offering would be of reduced attractiveness to its anticipated users. But would the ECB be prepared to ban access to TARGET2 to such a systemically important entity? What would the reaction of some very powerful and systemically important financial institutions that favour the Euroclear initiative be to such a decision? What messages would that give out regarding the future trajectory of an integrated European financial system? Would the central banks of the jurisdictions being linked by the Euroclear system and which appeared to have worked with the Euroclear designers and developers back such a ban? This "nuclear" option could not be exercised easily and the ECB eventually had to acknowledge that through a public statement (Godeffroy 2007) in response to a letter, also published in the Financial Times, from ECSDA, the European Association of CSDs (Cohen 2007, Mérère 2007). Euroclear itself also had a "nuclear" option in the form of a threat to cancel further development of its platform, the only actual concrete marketplace integration initiative with outputs that was putting into practice many of the European Commission Giovaninni recommendations. This was seen as a high cost to pay for the promise of the T2S system that only existed on paper.

Already, from the hostile reaction of the European CSDs, an indispensable constituency for the implementation of the T2S plan, the outlook for the ECB plan had started to look more uncertain. The uncertainty further increased following a report by a special panel for the European Union finance ministers demanding that the central bank delay a decision about developing T2S until the ECB "completes a feasibility study, assess cost structures and governance issues before taking a decision" (Grass 2007).

Though the outcome is still far from certain, it is easy to see how the durability of the two different assemblages is tested, how the weaknesses and strengths of the two are revealed in more detail, and more and more of the numerous entities they have to bring – and then hold – together are exposed. It is not only the system being assembled that is put to the test. External structures are also interrogated in the process and they are shown not just as simply being there ready to have an effect on the word and which innovation initiatives just bump into. Through their contact with such innovations, trials ensue that put these structures to the test and render them and their inscriptions explicit and contestable.

Conclusion

Through the apparently technical issue of interfacing with the new Eurozone TARGET 2 inter central bank payment system, a crucial dependency for the proposed Euroclear system, the Euroclear initiative became connected with wider contests and controversies regarding competing visions of what the EU is, what the role of the ECB in the EU should be, what regulatory philosophy regarding financial market infrastructures Europe will follow, what relationship will markets inside the Eurozone have with markets in the EU but outside the Eurozone, what implications does this have for concepts of national borders, sovereignty, and jurisdictions, whether national borders should be replaced by functional or system borders etc. Once this 'leak' has taken place and traced a path from inside the designers' boundary/front-line all the way to the board of the ECB, the EU Commission, the central banks of member states, and all actants in-between, a new settlement is needed. The genie cannot be put back into the bottle, and this can have huge implications for system designers.

Also, those on the outside of the cross-marketplace settlement system being developed by Euroclear are not just disinterested onlookers. They have their own interests and agendas and are busily working out their own strategies and approaches regarding any impending contact with the new system. This is what makes life for the designers of the new system even more difficult.

The world that the system they have designed has to be a part of is no longer the one that was there when their plans and models were being devised. They themselves, through their work, have changed it. New aspects have come to light, new issues, new controversies, new conceptualisations, new alliances, and new actants with new roles and many of these as a result of their own intervention and action.

The ECB was there when "Delivering a Domestic Market for Europe" was written, but it was a new organisation struggling to manage the launch and success of the massive project of Monetary Union and carve out a role for itself. Now it is no longer that. As its apparatus and confidence have grown, so has its interpretation of its remit. The patchwork of national RTGS payment systems that made-up the backbone of the previous TARGET pan-European payment system, an indispensable element of the proposed cross-border settlement system, is to be replaced by the purpose-built TARGET 2 system which the ECB wants under its direct control. But the ECB does not appear to share the approach to risk and regulation regarding market infrastructures displayed by the BoE when CREST was being developed and which was inscribed into the CREST system and its ownership and governance. Although it is still not clear what the reason for the ECB's proposal to develop a pan-European settlement system that could result in the Euroclear system being stillborn is, it appears that in the eyes of the ECB, the settlement system is too systemically important to the monetary and banking system of the Euro area for it to be delegated to a "user-owned and user-operated" ICT-based system. A new 'script' regarding the delegation of the organisation and regulation of securities settlement and, ultimately securities trading, is being put forward and it is, at the moment, in direct conflict with the Euroclear script and the conceptualisations of risk and regulation inscribed in it.

Eventually, the technical experiment of an ICT-based market integration initiative becomes embroiled in a broader trial of abstract conceptions of politico-economic integration out of which important future institutional and material arrangements relating to European (and broader) politico-economic integration will be shaped.

What would have happened to the abstract concept of a "Single European Capital Market" if an initiative such as the Euroclear Single Platform had not been attempted? The traditional answer would be: nothing. Politics goes its own way anyway. Another answer, however, could be: Everything. There is a wide spectrum of potentialities that could become a reality and these technologically inspired tests can be seen as political interrogations through which a certain reality starts to take a durable and material form. It is through the resolution of such struggles that, in the words of Akrich and Latour, "a privileged trajectory is built, out of an infinite number of possibilities"(Akrich 1992).

Marketplaces as algorithmic configurations

Introduction

Up to this point, the analysis has focused on the work of the developers of the new settlement system and seen the techniques and strategies they employ to bring together the elements that need to be assembled in order to make the new system a functioning whole and how, as this new system grows and gains in materiality it starts to act as an interrogation of the world around it. But what does this tell us about how these issues relate to markets and marketplaces as organised social spaces and their relationship with ICTs?

For markets and marketplaces to exist, chains of connections between a range of entities must be in place to make possible the reciprocal movement of the objects being exchanged between the separate worlds of the transacting parties and the heterogeneous networks they are part of.

Potential transacting parties have to first become aware of each others' presence as an available counterparty in relation to a particular exchange of a certain object or thing. They then have to reach some kind of agreement on the terms of this exchange and finally arrange for the actual exchange to take place, at which point the particular obligations among them – assuming everything goes smoothly – are extinguished and a finality in relation to that

specific transaction is achieved. The presumption of a trouble-free conclusion to a transaction and the achievement of finality are a prerequisite for the existence of a market and its calculative features (Slater 2002, Callon and Muniesa 2005, Millo, Muniesa, Panourgias and Scott 2005). Just as with computers and ICTs, a commercial exchange can be seen as a kind of interface linking the two separate settings of the transacting parties that must also allow for all relevant elements to cross between the two smoothly. The format must be compatible even if the data can vary.

Marketplaces and exchange architectures

As has been seen in the research, a great deal of effort and resources have to go into ensuring that transactions hold together until a point of irreversibility is reached and the way this is achieved in practice through a variety of arrangements of physical and institutional means defines particular concrete marketplaces, differentiating them from discrete commercial exchanges.

When considering what distinguishes a specific marketplace from the diversity and multiplicity of possible forms of market organisation, it is important, therefore, to pay attention to the common exchange architecture that describes a community of transacting parties. This exchange architecture is not just about the participating transacting parties. The objects being transacted – in this case securities – have to also be taken into account as must the organisation of the encounter between the transacting parties and the transacting parties and the objects of exchange.

A whole range of agents and objects must be defined and assigned roles that link these together according to a certain script. As Callon explains, the establishment of a frame that circumscribes these relations and defines the finality of a transaction is crucial to the operation of a market:

> "To negotiate a contract or perform a commercial transaction, effectively presupposes a framing of the action without which it would be impossible to reach an agreement, in the same way that in order to play a game of chess, two players must agree to submit to the rules and sit down at a chessboard which physically circumscribes the world within which the action will take place".

The development of the Euroclear Single Platform shows how the integration of five securities marketplaces involves a detailed re-articulation of such links between objects of exchange and exchange architectures and understanding how the two are related is not only important for the Euroclear designers but also sheds light on more theoretical issues regarding markets and marketplaces.

In the case of securities marketplaces, the exchange architecture that frames transactions and defines a certain organised social space is inscribed into the securities settlement system. It is the settlement system, itself a material expression of the legislation that governs the constitution and transfer of securities, that sets out *who* can transact (approved and paying participants/users of the system), *what* can be transacted (securities constituted, defined, and issued according to the relevant law and rules and regulations and accepted for settlement through the settlement system), and *how* a transaction is done (algorithms, electronic messages, processes, rules and regulations, roles, functions, exceptions, imposition of market discipline etc). The transactional script given material expression in the settlement system is intricately linked to the objects being exchanged and their definition in legislation.

In its pre-electronic configuration the settlement system for securities was defined by the circulation of paper securities certificates organised through the application of legislation, rules, regulations, and processes. The finality and irreversibility of a securities exchange was achieved with the amendment of an entry relating to the ownership of a particular security in an officially defined and recognised register or 'book' by a specified entity. These days, at the core of such a system there is an electronic ICT platform that assembles, sequences, processes, and reports transactions and links all market participants and the different elements of the platform together through a secure electronic message transmission network. At the core of such a platform is a computer algorithm that, once all the elements needed for the transaction to be concluded are in place, will, after freezing or blocking off these relevant resources, simultaneously detach and attach the assets being exchanged by the transacting

parties from and to their respective accounts and update an electronic securities register at which point the finality and legal recognition of the transaction are achieved and the accompanying property rights are conferred to the owners.

The complete and orderly disentanglement of the object of exchange from the worlds of the transacting parties, suggested by Callon as a necessary condition for the framing of a market transaction (Callon and Muniesa 2005), is thus achieved.

Securities as calculable goods

For the framing of a transaction to be possible in terms of the reciprocal obligations among the transacting parties and the achievement of finality, calculations also have to be undertaken. The terms of an exchange have to be agreed on, so the objects being exchanged have to be calculable through the establishment of some kind of comparability (Callon and Muniesa 2005). The price is the final link in the interface between the transacting parties that must be put in place for the two-way flow of the objects being exchanged to take place.

For this to happen, a double process of objectification and singularisation must be achieved (Callon and Muniesa 2005). The things being exchanged must be standardised as objects with stable and recognisable properties that make comparability and calculation possible. At the same time they must retain elements of particularity through which they become relevant and fit into the specific outlook of the transacting parties that gives that object a relative value compared to some other alternative object. As Callon and Muniessa write, it is this apparently contradictory dual process of objectification and singularisation that enables the objects of an exchange, at the moment of the exchange, to move easily between the sociotechnical networks of the respective transacting parties without the need for any calculative or other apparatus to be taken along (Callon and Muniesa 2005).

With securities, this double process of objectification and singularisation is linked to their constitution as securities that gives them very precise and

standardised characteristics as objects and simplifies their singularisation by reducing comparability to an issue of price and quantity as the other features of the object (property rights and obligations, method of transaction, fiscal treatment, dispute resolution etc) are standardised. The objects of exchange participate in the establishment of the particular exchange architectures of marketplaces.

A security is a legal right given to a creditor by a borrower, in this case the entity issuing the security and known as the issuer[121]. The integrity of the chains of reference that link creditors and borrowers in such a way that rights and obligations are clearly set out, mutually acknowledged, and above all upheld by the law, are a central feature of securities and play a role in the way the exchange of securities is organised.

In the example of equities (stocks and shares), it is through a legal codification and standardisation of the ownership, governance, and operation of economic entities and the inscription of the property rights and obligations thus established into easily transportable and exchangeable material objects such as share (electronic or paper) certificates, that the delocalisation, mobilisation, circulation, comparability, and connectivity of economic assets are brought about[122].

The delocalisation, mobilisation, circulation, comparability, and connectivity thus engendered also made possible the establishment of centres of calculation where comparisons and manipulations could be undertaken making possible further assessments and rankings of these economic assets (Callon and Muniesa 2005, p.1231). Stock exchanges can be seen as collective forms of

[121] The security can be represented either by a certificate or a book entry in a register. It may be bearer, meaning it entitles the holder to rights merely by physically possessing the security, or registered, meaning it entitles the holder to rights only if the holder appears on a register for that security maintained by the issuer or an intermediary. Under such a definition, securities can include shares of corporate stock, bonds issued by corporations or governmental agencies, options, and many other formal investment instruments.

[122] In the context of a national stock exchange, economic entities from any corner of a country were then in a position to attract investors from elsewhere in that country in exchange for a standardised and legally packaged portion of that economic entity with clear property rights and obligations and specified procedures for their transfer.

such calculative spaces in which competing calculative approaches and apparatuses interact with one another[123]. Through this competition and interaction a result is extracted; a new entity, the price, is produced (Callon and Muniesa 2005, p.1231). All this is made possible through the jurisdictionally achieved separation of economic assets from their context. It is this that makes possible their grouping into a new common frame, the establishment of original relations between them, and their classification and summing up (Callon and Muniesa 2005, p.1231). It is their packaging as securities that enable economic assets to be "materially and conceptually disentangled from their context" and constituted as discrete and transactionable items that can be passed easily from one context to another as property (Slater 2002, p.238). The standardisation of the frame thus established and inscribed into well-defined objects underpins the exchange and trading of these objects.

The jurisdictional boundedness of securities

The legal origins of this standardised packaging, however, limit their circulation to within a certain jurisdictional space. Its jurisdictional underpinning is part of the object being exchanged and therefore of the calculations that go into an exchange by the transacting parties. This is why it is has proved so difficult, despite the advances in ICTs, to disentangle securities from their local jurisdictional context without giving up some of their central features. There is always some trade-off between the mobility and immutability of these objects that transport claims, rights, and obligations.

The way economic assets are mobilised and inscribed into paper certificates (or structured electronic data entries in an approved computer system) is central to understanding the persisting local character of securities marketplaces in an increasingly globally organised financial services industry. This is because the mobilisation and circulation of these inscriptions is constitutionally related to

[123] Another thing that the Euroclear marketplace integration experiment helps to make explicit is the way that on either end of the attachment and detachment frame different price discovery mechanisms resulting from different modes of encounter between calculative agencies can exist. Collective forms of price discovery such as organised stock exchanges can use the same settlement arrangements as bilateral and OTC generated transactions or trades concluded over alternative trading platforms.

the jurisdictional space within which the laws that have brought them about apply.

Achieving this legally recognised transfer of ownership at a precise and unambiguous point in time and space across different jurisdictions has been one of the central design challenges for the Euroclear single platform developers. Their solution has depended on finding a way to ensure that the integrity of the chain of reference that links the creditor and borrower in such a way that rights and obligations are clearly set out, mutually acknowledged, and legally upheld is maintained, despite these parties being potentially in different jurisdictions[124].

What the Euroclear experiment in ICT-based marketplace integration has demonstrated is that it is possible to use ICTs to re-articulate the exchange architectures of five existing marketplaces without the need for extensive legislative change and in such a way that the jurisdictional boundedness of securities as objects of exchange is overcome, without losing the constitutive characteristics of the securities in question along the way.

The SSE – in effect – acted as an interface, or translation device, between the separate local market frames inscribed in the existing settlement platforms of the constituent CSDs, dealing with "the complexity of the various [legacy] systems with which it interfaces" (Euroclear 2002). The existing national legal and regulatory arrangements for the transfer of legal title to securities were treated as building blocks for the new cross-border system as were many elements of the ICT platforms already in use.

The following diagram illustrates this using the example of CREST settlement platform of the UK.

[124] In the UK, irrevocable transfer of legal title to a security in the CREST system was accomplished at the moment when the stock account of the receiving participant was credited. Since the approach to marketplace integration taken by Euroclear has sought to avoid the need for legislative measures and harmonisation, the designers have had to find a way of ensuring that existing legal provisions are upheld.

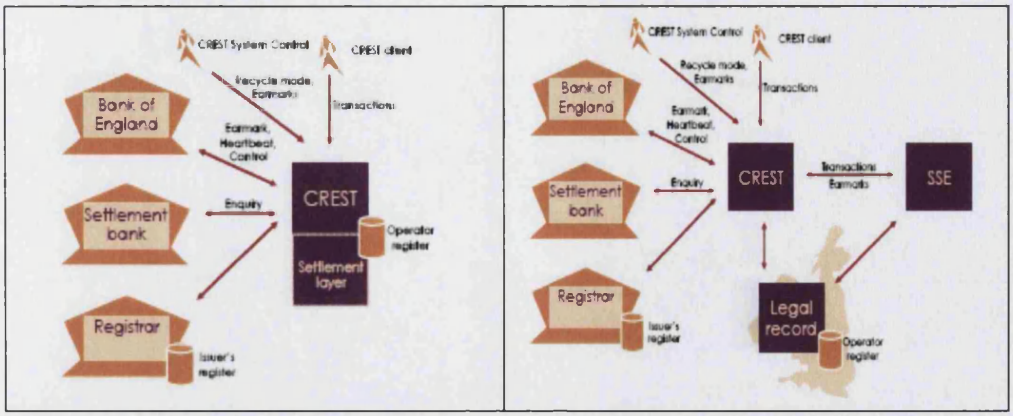

Figure 13: The disassembling and recombining of key components of the UK settlement system with the introduction of the Euroclear SSE (source: Euroclear)

In the original CREST system the Settlement Processor resided at CREST as did the Operator Register, where, according to UK law, legal title to ownership is conferred. In the case of CREST, as far as uncertified (i.e. in electronic form) securities were concerned, Members' stock accounts were considered as proof of ownership and so the Operator Register was represented by that database[125].

In order to be able to maintain the full range of property rights that define securities as objects of exchange and link them to specific jurisdictional spaces, the designers of the new cross-border settlement system had to find some way of preserving the link of the securities with the jurisdictions that define them, while also disentangling their actual settlement process from that same jurisdictional space. The high-level systems architecture similarities of the existing settlement platforms and the use of ICT systems interfacing and integration techniques made such a task possible and enabled the new system designers to take apart and rebuild, with both new and existing components, the existing settlement systems. New account structures and databases were developed in a way that ensured that the most common features with those in the existing settlement platforms were included and a specially formulated proprietary set of electronic messages for communication between the legacy settlement platforms and the SSE were developed in such a way that easy

[125] If the terms of issue of a security allowed for the security to be held in certificated (paper) form, the register would comprise of two parts, with CRESTCo maintaining the uncertificated part of the register, termed the "Operator Register of securities" and the issuer maintaining the certificated register termed the "Issuer Register of securities".

interfacing could be achieved and the process of disassembling and (re)combining could be made easier.

With the move to the SSE, there was no change to the fundamental architecture of CREST. The core settlement functionality (checking and positioning of resources, sequencing of transactions, movement of securities and cash) is "outsourced" to the SSE, which is both functionally and geographically separate. The Operator Register, however, which has to be maintained within the jurisdictional borders of the UK, will no longer be the users' securities accounts (now part of the SSE), but a new, separate, database that resides within UK jurisdiction and referred to as the Legal Record. As the SSE processes a transaction, at the point where the amendments to the securities and cash accounts of the transacting parties is ready to take place, the SSE will also update the "Legal Record" in the jurisdiction of the securities being transacted. DvP and the update of the Legal Record take place at the same time and thus the jurisdictional integrity of the securities is maintained and unambiguous finality is achieved.

As each local Legal Record needs to associate each security from that jurisdiction with an owner, it is also necessary for any potential holder from a jurisdiction other than that of the security to be created by the system in the jurisdiction of the security before a transaction can take place. In effect, the jurisdictional boundedness of the securities is overcome by mobilising the transacting parties and formatting their settlement arrangements in such a way so that they become compatible with, and can easily receive, objects of exchange from a different transactional frame.

Marketplaces and algorithmic configurations

As has been discussed previously, for reliable and predictable commercial exchange encounters to take place, a clear and unambiguous frame in which buyers and sellers are clearly defined and property moves in an uncontested way from one to the other is necessary (Slater 2002). For a transaction to reach finality, however, the terms of the exchange must also be agreed, whether explicitly or implicitly. This requires some form of comparability through

which different courses of action can be evaluated and even rudimentary kinds of calculations can be undertaken[126]. The calculative outputs of marketplaces are made possible "if goods can be calculated by calculative agencies whose encounters are organised and standardised to a greater or lesser degree" (Callon and Muniesa 2005).

This organisation and standardisation is not taken into account when seeing marketplaces only from the point of view of the coming together of transacting parties. The encounter between the transacting parties and objects of exchange that are calculable must also feature. It is this that defines particular common exchange architectures that differentiate markets and marketplaces from a collection of disparate individual exchange transactions. It is through the mutual shaping of the objects being exchanged and the exchange architecture within which exchange takes place, that actual marketplaces are defined.

For an exchange to take place, an 'interface' between the worlds of the transacting parties has to be established across which the two-way movement of the objects being exchanged must take place. While this will have many strands, such as the need for a clear and unambiguous frame in which buyers and sellers are clearly defined and property moves in an uncontested way from one to the other, the final link that makes the connection is the price. For a price to be reached, calculation, even in the form of a comparison, must be possible, so a standardisation of exchange objects is also presumed. The outcome of a transaction is a result of the interaction of all these elements.

This is the point where the value of the notion of marketplaces as algorithmic configurations proposed by Callon and Muniesa (Callon and Muniesa 2005) can be grasped. This proposes that, like an algorithm, a marketplace can be described as a concrete set of instructions that can be followed, contingent on a specific situation and/or task, and by working through these, a multitude of correct solutions can be attained (Callon and Muniesa 2005, p.1243).

[126] Even when a customer goes into a shop to buy something and where the prices are fixed and non-negotiable, he or she is, in effect accepting the terms of the exchange stipulated by the proprietor and in an indirect way a price is thus still generated.

Marketplaces are defined by a certain standardisation of such arrangements, but because it is difficult to separate these out, it has proved difficult to dislocate them and de-situate them. Prices, the outputs of marketplaces, by comparison, maintain their comparability even outside the local context of a concrete marketplace and can thus circulate and travel much wider. It is because of this lack of materiality and resulting mobility, combined with the use of ICTs, the cross-jurisdictional presence of large financial corporations, and the development of a legal arrangements that make possible cross-jurisdictional contractual arrangements among such corporations that the participation by remote transacting parties in still locally organised marketplaces is made possible. It is because of this that a global market in securities is assumed to exists.

This is also the point at which the role of ICTs in the functioning of markets in general, and financial markets in particular, becomes more apparent. As has been shown in this research, the script according to which how specified exchange objects such as securities are transacted, what entities are involved and what their competencies are, which calculative agencies have access to the system, and how their transactions are organised, have been transcribed from law into an ICT-based settlement platforms. Actual marketplaces have become computer algorithms. The value of this particular research setting has been that it provided a real-time observable experiment in integrating separate transactional frames through the incorporation into a single computer algorithm of the distinct algorithmic configurations of five different securities marketplaces. A new and shared algorithmic configuration is proposed based on a different ICT interpretation of the existing legally defined market frames. A new market configuration is brought into being without the need for legislative and regulatory changes, as had been the case when ICTs were first introduced to processing of securities transactions. Previously separate and distinct calculative agencies and objects of exchange are to be brought into the same frame by integrating their existing market frames into a common algorithmic configuration that treats them and processes their transactions in the same way.

While the dislocation of concrete financial marketplaces may be difficult for all the above reasons, the evidence from the Euroclear marketplace integration experiment has also demonstrated is that the relationship between objects of exchange and exchange architecture is not unique. There are different ways exchanges can be organised that still maintain the integrity of the object of the exchange and its properties. The mobility of locally entangled objects such as securities can be extended without having to necessarily sacrifice their immutability. It is because there is a certain mutual shaping of objects and architectures of exchange, however, that any integration or reconfiguration of exchange architectures also requires a careful and meticulous re-articulation of such relationships that goes beyond the integration of ICT platforms.

Once again, the role of ICTs in the integration of financial marketplaces is seen as much more than just simply enabling low-cost and fast interactions among remote transacting parties and dramatically expanding their calculative capabilities. Their role can only be fully understood by considering their involvement in the mutual shaping of goods, agents, and exchange arrangements that define actual marketplaces. Taking such an approach, for marketplace integration to take place a reconfiguration of a large proportion of the set of interrelations of the objects of exchange and the transacting entities involved must take place.

Securities as exchange objects carry with them, in the form of property rights and the way these are attributed and organised, a specification of the elements necessary for their detachment and attachment to take place with legal certainty. Other exchange objects such as money, sacks of cement, or cars carry with them different attachment and detachment scripts and interfaces. Different objects can be combined in different exchange architectures or algorithmic configurations if the necessary sociotechnical interfaces are in place. As long as the necessary elements are in place, there can be different interpretations of these scripts.

Ignoring any one of these central elements provides a skewed picture of a marketplace, how it works, and how it can be transformed. All have to be considered together and how they are shaped through their interaction. As Callon and Muniesa point out, "in real markets, the automation of financial markets and the organisation of e-commerce require detailed definition and analysis of algorithmic procedures" that cannot be "defined and described in an abstract way, independently of the material conditions of their enactment (Callon and Muniesa 2005).

From integrating marketplaces to reconfiguring markets

The notion of marketplaces as algorithmic configurations that make possible calculative encounters between calculative agencies and calculative agencies and objects of exchange is also useful in terms of extracting an answer to the main research question of this research project.

Why, despite the continually increasing capabilities of ICTs in terms of enabling ever faster and ever-cheaper remote interactions, actual financial marketplaces have remained locally organised?

The answer draws from the distinction between markets as abstract constructs and marketplaces as places where actual economic transactions take place proposed by Callon at the beginning of the Laws of the Markets (Callon 1998b) and from the discussion developed by Callon and Muniesa regarding the production of abstract markets out of the description and explication of the algorithmic configurations implemented in concrete marketplaces (Callon and Muniesa 2005).

ICT-based trading platforms and ICT-enabled global financial services providers have linked-up local marketplaces and made possible the trading of securities on a global basis, as claimed by Sassen (Sassen 2005, pp.20,22). ICTs can and do enable "physically distant and desynchronised entities to meet" and trade (Callon and Muniesa 2005). While cross-border calculative agencies involved in the trading of securities do exist and are engaged in exchanges through which prices are generated, their attachment and

detachment to and from the objects of the exchange are mediated through an often complex concatenation of intermediations and interfaces such as those provided by the custody banks. Benjamin describes such chains of intermediations as follows:

> "Such intermediation suggests the image of a series of Russian dolls, one inside the other, with the smallest doll containing a jewel. Each doll is different from every other doll, although the value of all the dolls derives alike from the jewel. The jewel equates by analogy to the underlying securities, and each doll to a different interest in securities."[127]

In this arrangement, in order to be made exchangeable outside the frame within which they are defined and circulate, and to move between transacting parties whose worlds are not formatted for easy attachment and detachment with these objects because of the lack of jurisdictional co-presence, securities have to be stripped of many of their property rights and simplified. In this way their connectivity and circulation is increased. There is, however, an obvious cost in terms of higher charges and increased risks, both due to the intermediation of the custody banks but also because of the reduced property rights and legal and regulatory safeguards that the objects in their original form would carry[128].

This is where the role of calculative agencies in this setting becomes important and where the value of the notion becomes clearer. As well as accommodating a distributed notion of calculation, the formulation of a calculative agency proposed by Callon and Muniesa (Callon and Muniesa 2005) avoids the need to specify in advance the precise role of those engaged in a marketplace transaction, why those actants are motivated to take part in a transaction, and what exactly the nature of the calculation or calculations they are making in relation to that transaction is. The importance of this approach was soon obvious in the research setting being investigated.

---

[127] In (Benjamin 2000, p.30).

[128] This complex arrangement based on intermediation has been built on an intricate system of multiple ownership that can result in what have become known as intermediation and legal risks. A more detailed account of the mechanisms involved and risks associated with the cross-border holding of securities through intermediaries is provided in Steven L. Schwarcz, and Joanna Benjamin, "Intermediary Risk In The Indirect Holding System For Securities", Duke Journal Of Comparative & International Law [Vol. 12:309].

The calculations involved in agreeing a securities transaction for a particular security at a particular price can be very different depending on whether the calculative agency involved is an individual, a pension fund, a hedge fund, or a corporation in competition with another corporation that is seeking to pursue a hostile takeover of its competitor. While their calculations might be based on completely different criteria and deploy different methodologies, devices, and understandings, they might still agree to transact at the same price. Furthermore, from among all these groups, taking away any shared interest they might have in the success of the Euroclear integration initiative as a consequence of their participation in the ownership and governance of the new corporate entity, there will have different assessments of the value of a cross-market and cross-border securities settlement system that makes possible the full transfer of legal title across jurisdictions.

These differences in calculation also contribute to the existence of marketplaces as they make possible a multiplicity of valuations among participants that give life to a marketplace through price movements. This is because through all their calculative equipment and apparatus, both physical and conceptual, the information flows they can tap into, the embodied knowledge and know-how of their personnel, and their participation in many different concrete marketplaces from which more information, knowledge, and know-how is generated, these calculative agencies, likely to take the outward appearance of multinational financial services corporations, can form, from all these combined resources, an abstract or mental picture of what the *market* for a particular good is.

It is this abstraction from actual marketplaces to markets that finally explains the question at the beginning of this research. As Sassen illustrates (Sassen 2005), financial *markets* are already global. In a sense they always have been, although the speed of their response has depended on the prevailing information processing and communication techniques. Actual financial marketplaces, on the other hand, where calculative agencies meet and encounter specific objects of exchange that require specific exchange architectures and algorithmic configuration in order to maintain their properties

and be calculable and attach and detach smoothly among the world of the different transacting parties, are much more difficult to dislocate and integrate. As has been shown, a great number of complex and interdependent relationships between a plethora of human and material actants and entities have to be taken into account in the latter case. Some must be kept in tact, other replaced, others dissolved and re-assembled in different ways, and some entirely new ones devised and assembled with those already there. These relationships that link transacting parties, objects of exchange, and exchange architectures have to all be taken into account in any process of redesign and their often complex articulations have to be meticulously analysed, understood, disassembled and recombined.

It is in their function as bridges between such islands of localised financial activity that the global scale, importance, and wealth of multinational financial services providers can be understood. Increasingly globe-spanning and virtualised ICT-based meta-markets have come about, but one cannot consider these in isolation from the still spatially and jurisdictionally localised concrete marketplaces that underpin them and that form an indispensable link in the chains of reference that help connect these global meta-markets to actual material economic assets and activities on the ground.

It is because of this that even in an age of improved ICT interoperability, a glut of electronic communications bandwidth, the existence of the internet, ever-increasing processing power, and diminishing ICT costs, the integration of financial marketplaces has proved to be much more difficult than anticipated, needing much more effort to bring about than initially assumed. The assumed links between globalisation, finance, and ICTs are in fact much more complex, complicated, and nuanced than at first appears to be the case. Electronic ICTs have removed spatial separation as a limitation on the ability of calculative agencies to transact with one another, have made possible an explosive growth in the volumes of transactions that can be processed at any one time, and helped reduced the cost of such transactions. This has made possible a global market in financial assets of most kinds, but this is not a marketplace were legal title to ownership and the property rights that accompany such ownership

are transferred, but one in which, through the intermediation of global financial service providers, transacting parties, as beneficial and not outright owners, can gain or loose from the price movements and performance (dividends, interest payments) of the assets owned in this fashion, but may not be entitled to vote on the AGM of a corporation for which they own a substantial shareholding.

The cross-border transfer of actual financial assets has so far proved elusive. Despite continuous advances in ICTs there are still very few examples of cross-border markets where an actual movement of the underlying assets takes place. It is this that Euroclear initiative is trying to achieve in practice using ICTs. If it is successful, participants of the settlement system, whether they are in the UK, Ireland, France, Belgium, or the Netherlands will be able to transfer to each other full legal title to securities issued anywhere in these jurisdictions without any diminution of the property and other rights inscribed into those securities and with the entire chain of reference that links borrower and the lender still in place.

While the objects of exchange will have remained unchanged, a new common ICT-based interpretation of the algorithmic configuration necessary for their exchange has been assembled that enables transacting parties from all the marketplaces integrated, to own and dispose of securities from the other marketplaces. The securities themselves and their properties and legal dimensions might have remained unaffected and maintained their jurisdictional and other distinctions, but new common mechanisms for their attachment and detachment and for the achievement of finality will have been put in place.

Inevitably, the integration of these separate marketplaces will also reconfigure the existing global financial markets as expressed by the calculative agencies that constitute them and link-up the concrete local marketplaces. In a sense, five local marketplaces have been replaced by one regional marketplace. But this new concrete marketplace is just as much local – if also substantially bigger – in terms of the abstract global market as the marketplaces it replaces. This, however, is still enough to have important reconfigurative implications at the level of the abstract global market. Economic theory is once again turned to

in order to provide the guidebook to this new landscape. One big pool of liquidity instead of five smaller ones might be expected to lead to less volatility and better prices. A number of barriers to comparability and calculation will have been removed resulting in a better allocation of capital to economic entities on the ground and leading to superior economic decisions and results that, might, in turn attract more investment. New knowledge is produced and new states of the world taken into account.

Conclusion

What can be learned about marketplaces and markets as concepts from the Euroclear integration experiment studied in this research project and how do ICTs fit into such conceptualisations?

What the analysis developed here has shown is that there is more to marketplaces and markets than the simple coming together of transacting parties for the purpose of an economic exchange. It is because of this that the ability of ICTs to make possible the cheap and fast interaction of remote transacting parties with vastly increased calculative capabilities contrasts so starkly with the continuing fragmentation and local organisation of actual financial marketplaces.

Marketplaces are more than a meeting place, virtual or physical, for those interested in transacting. They are a complex arrangement of interdependent agencies, objects, and procedures that format economic exchanges, framing them in such a way that they can be brought to a predictable and orderly conclusion and all the calculations necessary for the transacting parties to engage in a transaction can be performed.

The analysis presented has tried to show how in the case of securities, their constitution as objects of exchange is central to their calculability and the framing of transactions and how this is intricately linked to laws and a specific jurisdiction that limit their mobility and circulation. The constitution of securities as exchange objects through legislation provides the stable and mutually acceptable frame that makes possible their disentanglement and

alienation as objects of exchange that are thus able to move between the sociotechnical networks of the transacting calculative agencies. Regardless of the particular individual securities being transacted, a securities transaction in a particular jurisdiction is always treated and processed in the same way in order to have legal substance. A precise configuration or script for the exchange is specified with clearly defined roles and responsibilities for all the entities, both human and non-human involved in the transaction. What can be transacted, how it can be transacted, and who can transact are laid out in law and then translated into ICTs . A clear frame that outlines a boundary with identifiable and stable entry and exit points is established. Groups of calculative agencies and objects of exchange are also defined and their interrelations specified. Transactions, while singular in terms of price and quantity at a particular moment in time, are thus also standardised, mutually understood and accepted, and repeatable in large aggregate numbers. While each transaction is unique and different, they can also all be treated in the same way. This is how the move from individual exchange transactions to aggregate notions of marketplaces as social spaces is effected.

The way economic assets are mobilised and inscribed into certificates or structured electronic data entries in an approved computer system is of central importance to understanding the persisting local character of securities markets in an increasingly globally organised financial services industry. This is because the mobilisation and circulation of these inscriptions is circumscribed by the jurisdictional space within which the laws that have brought them about and govern their exchange apply. It is through a legal codification and standardisation of the ownership, governance, and operation of economic entities and the inscription of the property rights and obligations thus established into easily transportable and exchangeable material objects such as paper share certificates that a delocalisation, mobilisation, circulation, and connectivity of economic assets is brought about.

As Slater suggests (Slater 2002), markets are primarily defined in terms of organising the "alienation and transfer of goods in the form of property" and for this purpose often complex sociotechnical apparatuses "to establish both

alienability and its limits" are required (Slater 2002) with the calculative functions of a market following on from this. By studying the design and development of a cross-border securities settlement system, the assembling of exactly such a sociotechnical apparatus for the establishing of the "alienability and its limits" of securities in a new cross-jurisdictional market frame has been traced. The resulting account demonstrates how ICTs are directly implicated in the defining of "alienability and its limits" and the framing and overflowing that goes with that and the contests and controversies that are generated in the process.

While at first it appears that this link between securities and jurisdiction extends to the exchange architecture, or algorithmic configuration, of particular concrete marketplaces, the real-time market integration experiment studied in this research shows how, thanks to the standardisation and easy disassembling and recombining of linkages made possible by the translation of such algorithmic configurations into computer algorithms, different ICT interpretations of exchange architectures are possible.

Global financial services corporations can and do trade securities outside their jurisdiction, but those securities still remain relevant only within the jurisdiction of their issue. Remote access to settlement systems and cross-border securities transactions using the services of intermediaries such as custodians or bilateral links between CSDs are possible and do take place, but the objects of the exchange lose many important properties in the process because the property rights associated with the securities only have meaning and enforceability within the jurisdiction in which the securities have been issued. This is the difference between the kind of cross-border meta-market for securitises that already exists via the intermediation of the custody banks with many of the jurisdictional elements of the exchange objects stripped out and the one being developed through the kind of detailed re-articulation work involved in the design and development of the Euroclear Single Platform.

The plan to integrate five separate existing securities marketplaces aims to make possible the combination five separate pools of liquidity thus realising

some very substantial network effects and making the value of the resulting network of potential transacting parties more than the sum of its parts. For this to happen, a delicate disassembling and recombining of the elements that have come together to form these legacy marketplaces must be attempted, but in such a way that it will preserve the characteristics that have made these existing marketplaces important and valuable up to now. The existing networks and liquidities have to be kept in place, but for this to happen, the particularities of the objects of exchange must be maintained, as must be the chains of attribution and reference that give them their value and define them as objects. It is not enough to enable more transacting parties from further away to encounter one another. It must be possible for them to transact different objects of exchange constituted in different jurisdictional spaces over a common architecture of exchange.

Such a common architecture of exchange not only makes possible cross-jurisdictional transactions and assists cross-border mergers and control and governance of corporate entities, but by providing a common frame for the transaction of many different types of securities, also facilitates the design and automated trading of complex combinations of financial assets that underpin complex derivatives. Through such "efforts in abstraction", undertaken by the calculative agencies that transact in concrete financial marketplaces, markets are performed. By understanding this mutually defining relationship between marketplaces and markets and the role of calculative agencies in it one can dissolve the paradox of global financial markets and local marketplaces and why ICTs, despite the continually increasing capabilities in terms of enabling ever-faster and ever-cheaper remote interactions, actual financial marketplaces have remained locally organised.

Conclusion

It is undoubtedly true that the increasing adoption and proliferation of electronic ICTs in finance has had important implications for market-based interactions. ICTs have made it possible for remote transacting parties to encounter each other and negotiate the terms of an exchange across geographical distances and territorial boundaries (Sassen 2005). Such technologies have also made possible dramatic increases in the volumes of transactions that can be processed and reductions in the cost and time needed to process transactions (Sassen 2005).

Actual concrete financial marketplaces, however, have remained distinct and non-global (Group of Thirty 1988, 1990b, Giovannini Group 2001, Group of Thirty 2003), despite a semblance of globalisation imparted to them by the existence of global-scale financial service providers who have used ICTs and their networks of subsidiaries and/or local agents to provide the necessary intermediation for cross-border financial transactions to take place. These financial intermediaries, in effect, act as bridges linking together, in a global patchwork, disparate and discreet marketplaces.

Compared to physical goods, the exchange of financial assets can appear frictionless (Sassen 2005), but as the research has shown with the case of securities, their immutability as objects and their exchangeability come from complex entanglements with particular local sociotechnical arrangements and structures. This can mean that the extinguishing of the obligations created by a transaction, through the delivery of the objects being exchanged, can be as spatially constrained for financial products as that for physical goods. Maybe even more so, as physical objects, unlike jurisdictionally specific financial objects, usually do not loose their characteristics and meanings through geographical or jurisdictional displacement. These observations point towards some kinds of disjuncture between jurisdictional, geographical, and ICT spaces in the exchange of financial assets.

Before the introduction of digital electronic ICTs, the exchange of financial objects was constrained by their physicality, so geographic and jurisdictional spaces appeared closely aligned for most practical purposes to most transacting parties. The introduction of electronic ICTs to financial transactions has undoubtedly removed many of the constraints of physicality and geography on the exchange of financial assets. The circulation of financial objects has moved from a physical-geographical space to an electronic ICT space defined by the relations and interconnections of computers and telecommunications networks and the circulation of electronic messages. While this may have made possible the coming together of previously geographically remote transacting parties and the negotiation of the terms of a transaction between them, the issue of the actual delivery of the objects of the exchange remained problematic. This is because, as discussed in chapter three in the section entitled "*Securities and the mobilisation of the world*", the objects being exchanged in financial transactions are often only able to exist and circulate in specific jurisdictional spaces. Key elements of the attachment and detachment processes that make a market exchange possible by establishing "a stable and reliable context in which objects and obligations are clearly mapped out and can be intersubjectively recognised" (Slater 2002) and that allow objects of exchange to move in an unproblematic way between the worlds of the transacting parties, are likely to be missing, if one or both of the parties are outside the jurisdictional space in which these objects have meaning and can circulate. To use Slater's concept (Slater 2002), new "separative technologies" are needed that can enable jurisdictionally specific exchange objects to be "materially and conceptually disentangled from their context as discrete and transactionable things" and become "items that can be passed from one context to another as property" (Slater 2002). As has been shown, this detachment and attachment process is especially complex and fraught to achieve across jurisdictions in practice, in the case of securities (stocks and shares, bonds, money market instruments etc), which are defined through law, have specific property rights and obligations assigned to them in specific jurisdictions, and the modalities of their transfer are very precisely specified if their legal dimension is to be preserved.

As discussed in chapter three in the section entitled "*The settlement system and the framing of securities transaction*", in securities marketplaces, the "separative technology" that makes possible a clear framing of transactions and that sets out in a material way what can be exchanged, by who, and how this exchange is organised, is the settlement system. It is within this system that the final strands linking the objects being exchanged are detached from the world of one transacting party and attached to that of the other, enabling the movement of the objects of exchange to be concluded and the finality of the transaction, through the settlement of open obligations, to be achieved. For this to happen, all other entanglements, apart from those to be treated by the settlement system, must have already been resolved. If this progressive reduction in the entanglements of the objects of exchange involved in the trading of securities leading to the final settlement of an obligation has not taken place, the settlement algorithm at the core of the settlement system simply rejects the transaction and it fails.

As the history of CREST (see Appendix E for a summary) and accounts of the dematerialisation of securities in the UK and in other countries show (Smith 1996, Currie 1997, Currie and Willcocks 1998, CRESTCo 2002a, Willcocks and Hindle 2004, Interview D 2006), the introduction of electronic securities settlement systems involved a process of legal and technical co-elaboration. Ultimately, however, it is legislation that defines the requirements that a securities settlement system must fulfil in order to gain approval and legal status as a settlement system and that sets out how and where, within such an approved system, final and irrevocable transfer of ownership to property over the objects being exchanged is effected. It is the jurisdictional elements intertwined with the technical and material elements in electronic securities settlement systems that, despite the dematerialisation of securities, have prevented truly global actual securities marketplaces from coming into being. There is a misalignment between what is possible at the ICT level and what is possible at the jurisdictional level. For a cross-border securities marketplace to exist, such misalignments have to be resolved. The Euroclear initiative studied in this dissertation can be seen as an experiment to overcome such

misalignments through the use of techniques of ICT integration. As the research has shown, to do this, a careful and meticulous disassembling of particular local techno-juridical frames and recombining into new ones must be undertaken that preserves the characteristics and chains of reference and claims that underpin the jurisdictionally defined exchange object in question, the security.

While even without a purpose-built cross-border settlement system there has been cross-border trading in financial instruments such as securities, this can be seen as a kind of meta-market. The securities are traded through the intermediation of financial service providers such as custody banks, but are stripped of more or less significant aspects of their jurisdictional properties that take the form of property rights (Benjamin 1996, 1998, 2000, Schwarcz and Benjamin 2002). In such a setting, the owners of the securities benefit or loose from the price movement of the securities thus owned and enjoy any resulting dividends or interest payments, but are not the outright owners of legal title to the property in the same way that an owner within the jurisdiction of the security would be. They are what are referred to in the financial sector as "beneficial owners" of "indirect holdings" and their property rights come as a result of a contract or service agreement with their financial intermediaries rather than through statute [129].

As the volume, value, and complexity of cross-border and cross-marketplace securities transactions has grown and conceptualisations of legal risk have gained wider currency (Committee on Payment and Settlement Systems 1995, Giovannini Group 2001), this state of affairs is seen increasingly as problematic, both by large sections of the financial services industry and public policy agencies, due to what are seen as the risks, costs, and inefficiencies inherent in such arrangements[130]. This is even more the case in Europe where

[129] More details of such arrangements can be found in (Benjamin 1996, 1998, 2000, Schwarcz and Benjamin 2002)

[130] The Giovannini Report shows that a cross-border securities transaction within the EU can involve up to 11 intermediaries and a minimum of 14 instructions (plus a similar number of accompanying confirmations), compared to a maximum of 5 intermediaries in a similar domestic transaction (Giovannini Group 2001, p.15). Apart from the inefficiencies that result from such intermediation, purely in terms of the extra fees involved and the extra time taken

the unfolding project of establishing a single market in goods, services, capital, and labour is seen as suffering from the fragmentation of capital markets.

The experiment in European market integration being pursued through the European Union (EU) has been based on politico-legislative initiatives through which a new jurisdictional space that coincides with an expanded geographical space is being forged. Taking such an approach in the case of securities markets would entail the development and approval through the decision-making channels of the EU of the necessary juridical instruments to institute common pan-European property rights for securities and regulations regarding their transfer inscribed into some kind of Euro format of securities. These would then be traded the same way around all European capital markets that would have to change their arrangements in order to accommodate transactions in such products.

It was generally assumed that, because of the legal specificity and resulting entanglement of securities, it would not be possible to integrate Euroepan securities marketplaces without substantial legal harmonisation initiatives[131]. The progress of the experiment in technological and operational rather than politico-juridical market consolidation undertaken by Euroclear that has been traced in this research, shows that there might be another, ICT-based, way to try and integrate marketplaces for securities, notwithstanding the issues raised by their jurisdictional entanglement.

---

for a transaction to be completed, the number of things that can go wrong at each stage of the transaction as well as the probability of something going wrong also increases. In addition, the reliance on multiple custodians in multiple jurisdictions also introduces risks of insolvency, fraud, or negligence, conflicts of law and regulation, unenforceability of contracts, and unexpected applications of the law (Committee on Payment and Settlement Systems 1995, Giovannini Group 2001).

[131] The following extract from an official submission by BNP Parisbas, one of the biggest custody banks in Europe, to a consultation process on clearing and settlement in Europe conducted by the European Central Bank is indicative of this assumption: "The emergence of a single CSD will require the harmonisation of both the European tax and legal frameworks. In effect, equities and UCITS are subject to regulatory, fiscal and legal constraints (company law, securities finality law, bankruptcy law, ...) which are specific to each country. Unless European harmonisation is implemented, the consolidation of settlement systems (to implement a centralised model) will either remain a utopia, or have legal impacts on the underlying securities. ... The technological and operational consolidation which was the objective of the [Euroclear] merger ... can take place only on the basis of legal, fiscal and regulatory harmonisation of the countries involved (BNP Paribas Securities Services 2002, p.27)".

Far from being a straightforward ICT integration exercise, however, the work of the Euroclear settlement system designers and developers traced in this research has involved an intricate taking apart and re-assembling of new and existing sociotechncial elements to form a new integrated marketplace. There has been as much social as ICT engineering involved in this articulation work. Roles, ways of doing things, rules, practices, processes, regulations, and tax arrangements have had to be altered as much as electronic message formats, database structures, algorithms, account structures, computer hardware, and data communications protocols and networks. All these have had to be fitted and held together in an unproblematic and durable way and this durability is imparted through the successful intertwining of both social and technical elements[132].

This finding, specific to the development of a new ICT-enabled transactional space, fits with a more general critique made by Thrift of 'new era' accounts of information spaces:

> " ... new technologies were rarely seen as part of a linked repertoire of practices. But no technology is ever found working in splendid isolation as though it is the central node of the social universe. It is linked – by the social purposes to which it is put – to humans and other technologies of different kinds. It is linked to a chain of other activities involving other technologies. And, it is heavily contextualised."[133]

In the specific case being studied here, rather than trying to find a way to use ICTs to disentangle securities from their jurisdictional space or create a new jurisdictional space within which they can circulate, the alternative approach developed by Euroclear leaves the object of exchange free to circulate within its existing local jurisdictional space, but enables the transacting parties to inhabit multiple jurisdictional spaces through the functionality of the new settlement platform. Moving the transacting parties, which are not as

[132] This echoes some of the "six generic lessons" identified by Willcocks and Hindle from a comparison of attempts to move markets "from place to space" included in their follow-up study of modernisation initiatives at the London Insurance Market (Willcocks and Hindle 2004, p.12).
[133] In (Thrift 1996, p.1468)

jurisdictionally entangled, effects movement across jurisdictions relative to the objects of exchange that remain jurisdictionally fixed. Through the clarification, harmonisation, and standardisation of links and elements and the re-framing of the marketplaces involved that this makes possible, it becomes feasible for transacting parties from different jurisdictions to attach and detach easily from exchange objects in other jurisdictions. Rather than trying to make the exchange object fit into the world of the transacting parties, an element of the world of the transacting parties (their attachment/detachment interface) is changed and standardised in such a way as to enable them to attach and detach easily with exchange objects in a multiplicity of local jurisdictional spaces.

Although ICTs are a necessary component for such a marketplace re-articulation project, it is through the meticulous weaving together of ICTs and other human and non-human entities and networks that the new cross-border market frame for securities is being realised. It is when all these fit together in an unproblematic way that a new marketplace will become durable enough to become a reality.

It is in this process of fitting together and the issues this throws up that the truly heterogeneous character of a financial marketplace and a securities settlement system become evident. As shown in the research by the controversies relating to cross-central bank payments, withholding tax, and investor IDs, even apparently small technical misalignments or points of friction can erupt into wide-reaching controversies that bring into the design and development process numerous actants from many other settings. A link can suddenly be established between the presence or absence of a field in a database and questions relating to issues of personal privacy, data protection, banking anonymity, tax evasion and so on. Interfacing with the central bank payment system can end up being about a clash of regulatory philosophies. It is at points in the process of assembling this new sociotechnical network that the smooth fitting together and intertwining of ICTs and other human and non-human entities becomes problematic, that the heterogeneity of the system is made explicit and manifest. Previously stable social and technical entities can then start to unravel and get dragged into other controversies; trials ensue out of

which some kind of resolution is arrived at. It is only when some kind of new durable accommodation is achieved as a result of such trials that the smooth fitting together can continue.

In this way, as more and more elements get fitted together successfully and the durability of the unfolding assembly increases, encounters with other already durable sociotechnical assemblies that have resisted the enrolement proposed by the system designers test the durability of the entity being developed. Having gained in materiality, the new assembly starts to act as a concrete interrogation of the world around it and, in the process, shows how external structures shape, but are also shaped by, their interaction with the new emergent entity.

As the research has shown (pages 140-141), the boundary of the new market frame is thus pushed, articulation by articulation, further outwards from the algorithmic core of the settlement platform to include more and more entities until the new cross-border marketplace is eventually fully enclosed in it and its entry and exit points become stabilised and controllable.

While a number of important issues have been raised through the research, the starting point of this project had been to contribute to a better understanding of the relationship between ICTs and financial markets. As outlined in the introduction, this interest was provoked by the apparent contradiction between the undeniable growth of cross-border financial activity, the proliferation of narratives dealing with both markets and ICTs anticipating a massive integration of financial markets on a global scale, and the observable reality of stubbornly non-global and discrete financial marketplaces.

It was an early assumption of this research project that part of the reason for this contradiction was the use of ready-made conceptualisations of markets and technology. As a result, it was felt important to find a way of studying empirically how these two notions are related in practice, but in a way that did not rely on ready-made conceptualisations. Actor network theory, with its insistence on approaching research settings without any preconceived notions

but simply as heterogeneous assemblages of human and non-human entities to be studied through the tracing of the relations and associations linking these entities, was seen as the most appropriate way of pursuing this objective. In particular the social studies of finance (SSF) research agenda that has sought to bring perspectives from the broader science and technology studies research agenda to the study of finance, was seen as providing a good platform from which to approach the research problem outlined. Having made this choice, it is ultimately back to these bodies of literature that the research project must also deliver inputs and contributions.

One contribution has been to test some of the tenets of actor network theory and SSF and some of the insights developed from them in the empirical setting studied. Some of these relate to the design and implementation of the research. One example of this has been the idea of a "semiotics of technology" proposed by Latour and Akrich (Akrich 1992, Akrich and Latour 1992, Latour 1992, 1993, 1996b) that this research has attempted to implement. Another has been the innovative approach to the use of documentation that sees project-related documents as integral parts of the sociotechnical network being assembled (Latour 1993, Preda 2002, Cooren 2004) and uses them as a way through which to identify and then follow the progression of the articulations between human and non-human entities proposed in the designers' scripts, from concept and words to thing. The central contributions, to these two literatures, however, relate to the conceptualisation of ICTs – or lack of it – found in them and how this relates to the involvement of ICTs in the reconfiguration of a sociotechnical network such as a securities marketplace.

Actor network theory has provided radical insights into the notions of technology and technological objects and artefacts and how to study them. Through their extension to economics (Callon 1998b, Barry and Slater 2002, Callon, Barry and Slater 2002), such approaches have contributed to the re-conceptualisation of markets and marketplaces (Callon and Muniesa 2005), the elucidation of relations between economics as a discipline and practical economic activities (MacKenzie and Millo 2003, MacKenzie 2006, MacKenzie, Muniesa and Siu 2007), and the highlighting of the artificiality of

the separation of economic and other activities by suggesting new ways of re-conceptualising calculation (Callon 1998b, Callon, Barry and Slater 2002, Callon and Muniesa 2005). There is little, however, that relates *specifically* to digital electronic ICTs and their involvement in the dramatic changes in many kinds of interaction that have taken place over the past three decades (Hanseth, Aanestad and Berg 2004).

It should not come as a big surprise that actor network theory (ANT), with its emphasis on avoiding the use of arbitrary categories and prefabricated conceptualisations in studying a research setting and its insistence on understanding how categories, concepts, and objects are assembled out of human and non-human elements, does not have a specific conceptualisation of information and communication technologies (ICTs). Latour makes this point himself when he writes about using ANT for studying information systems in a fictitious dialogue with an imaginary student of information systems:

> "The best [ANT] can do for you is to say something like: 'When your informants mix up organization and hardware and psychology and politics in one sentence, don't break it down first into neat little pots; try to follow the link they make among those elements that would have looked completely incommensurable if you had followed normal academic categories'. That's all. ANT can't tell you positively what the link is. ... I would say that this computer here on this desk, this screen, this keyboard, as objects, this school are made of multiple layers, exactly as much as you, sitting here, are: your body, your language, your questions."[134]

While a number of people have sought to use actor network approaches in a variety of ways to study ICTs, (Adams and Berg 2004, Allen 2004, Faraj, Kwon and Watts 2004, Hanseth, Aanestad and Berg 2004, Mahring, Holmstrom, Keil and Montealegre 2004, Marres 2004, Moser and Law 2006), in the writing of Latour, ICTs are seen primarily as part of the broader mobilisation of the world through inscriptions, as the following passage from *"Science in Action"* shows:

> "If inventions are made that transform numbers, images, and texts from all over the world into the same binary code inside computers, then

[134] See (Latour 2004).

> indeed, the handling, the combination, the mobility, the conservation and the display of the traces will all be fantastically facilitated."[135]

In *"Pandora's Hope"*, in the chapter on the "Circulating Reference" that follows the work of soil scientists in the Amazonian forest of Brazil, Latour again discusses the mobilisation of the world in some detail, as the data gathering of the scientists gradually transforms things into signs and their work moves from the concrete to the abstract. Again a form of ICTs, in this case the fax, is seen as implicated in the increased mobilisation that this move from things to signs makes possible:

> "As abstract as the pedocomparator [soil sampling instrument] is, it remains an object. It is lighter than the forest, yet heavier than the paper [on which a diagram of it is drawn]; it is less corruptible than the vibrant earth, but more corruptible than geometry; it is more mobile than the savanna, but less mobile than the diagram that I could send by telephone if Boa Vista had a fax machine."[136]

In the Social Studies of Finance literature there has inevitably been a greater engagement with ICTs, with studies of the introduction of ICTs to the Paris Stock Exchanges (Muniesa 2000, 2004, 2007), the use of the telephone in OTC trading rooms (Muniesa 2002), the importance of ICTs in arbitrage trading (Beunza, Hardie and MacKenzie 2006), and changes in trading practices brought about by the virtualisation of trading through electronic displays and screens (Knorr-Cetina and Bruegger 2002, Knorr-Cetina 2005). While there is a focus on settings where ICTs are involved in the trading and price-production aspects of market transactions and on the importance of ICTs in terms of their ability to "allow physically distant and desynchronised entities to meet [in order to transact] and constantly renew that encounter" (Callon and Muniesa 2005, p.1242), there are also points made regarding the involvement of ICTs on the framing and configuration of financial interactions. Beunza, Hardie, and MacKenzie, for example, show how ICTs participate in the conceptualisation of a trading strategy:

---

[135] In (Latour 1987, p.228)
[136] In (Latour 1999, p.54)

> "... human actors in financial markets are not 'naked': their equipment goes beyond their bodies, consequential as the latter sometimes are. This equipment is part-technological, part-conceptual. The 14s/40s [Brazilian government bond] trade, for instance, was not just an idea thought up by partners A and B. It was prompted by the physical traces of prices on a computer screen, checked by constructing a material representation (the assistant's price chart), and circulated in the form of the bits encoding an Excel file."[137]

Building on the study of the computerisation of the Paris stock exchange and drawing parallels between computers and markets as "organised social spaces" that circumscribe a group of agencies, organise their encounters and connections, and establishes the rules and conventions that govern the resulting interactions, Callon and Muniesa develop the notion, also put forward by Mirowski (Mirowski 2007), of markets as algorithmic configurations and point out how "with new information technologies, the power and diversity of encountering technologies are amplified" to the extent that "configurations become objects in their own right" (Callon and Muniesa 2005, p.1242). They point out that the design and realisation of these configurations are not simple technical issues, but sites of "an intense struggle" between market participants and designers in which ICTs are also implicated (Callon and Muniesa 2005, p.1243). Through such struggles market architects and stakeholders are put to the test of 'explicitness', as explained in the following passage:

> "[Market designers] continuously face 'trials of explicitness', i.e. situations for which a course of action requires the display of empirically articulated problems and solutions, situations that are particularly common with computers."[138]

So, having reached the end of this research project, what further can be said about the conceptualisation of ICTs found in the two main literatures that have informed it and how do these findings relate to the involvement of ICTs in the reconfiguration of financial marketplaces?

One point that this research has brought to the fore is that, while the ability of ICTs (whether these are telephones, telefaxes, or computers using secure data

[137] In (Beunza, Hardie and MacKenzie 2006, p.739)
[138] See (Muniesa 2007, p.381)

networks or the internet) to make possible the participation of remote transacting parties in concrete local financial marketplaces is undeniable, and in this sense their involvement is very much along the lines of the "fantastic facilitation" of the mobilisation of the world suggested by Latour (Latour 1987, p.228) or in terms of their ability to "allow physically distant and desynchronised entities to meet [in order to transact] and constantly renew that encounter" (Callon and Muniesa 2005, p.1242), there was also something more going on.

While the introduction of ICTs to securities markets through the so-called dematerialisation of certificates and the replacement of paper documents by electronic data entries in legally approved and designated databases has, to use Latour's words, transformed "numbers ... and texts from all over the world into the same binary code inside computers" (Latour 1987, p.228), the mobilisation of the securities themselves had not been "fantastically facilitated". While their handling, combination, conservation, and display have undoubtedly been enhanced, their mobility has only increased in terms of speed, but not distance. Undoubtedly, the prices generated in the actual local marketplaces where securities are traded have been mobilised to an incredible degree and remote electronic access, usually through intermediaries with a presence in many jurisdictions, has made it possible for transacting parties from any part of the world to trade almost instantaneously on any particular local financial marketplace. The securities themselves, however, and the unbroken chain of claims, rights, and obligations linking borrower and lender they frame, remain jurisdictionally bound. Just like a fax of the diagrams produced from the pedocomparator data by the soil scientists followed by Latour (Latour 1999) would be a meaningless scribble if received by anyone other than a fellow soil scientist, so the electronic data entries used to represent a security would be meaningless and worthless electronic impulses outside the combination of jurisdiction and computer system within which they have meaning and value[139]. It is a crucial point and one that is linked to the shift in

[139] The issue is similar to the one discussed by Mol and Law in relation to the definition of anaemia in different regions and the implications of this for the conceptualisation of social spaces (Mol and Law 1994).

focus in actor network theory from simple links in the earlier literature towards notions of framing and overflowing and entanglement and disentanglement developed later in order to deal with more "complicated relations" and the "dynamics involved in reconfiguring entities and networks of entities" (Callon, Barry and Slater 2002, pp.293-294).

As has been shown, and discussed earlier on in this conclusion, the mobilisation of securities requires a radical and meticulous reconfiguration or reformatting of many of the relationships that constitute the exchange architecture that enables their trouble-free movement among transacting parties so that they can retain their meaning and value that is linked to their immutability even in transactions among counterparties in different jurisdictions. The research describes clearly the point made by Callon that "in order to make disentanglement possible, economic agents heavily invest in the production of entanglements" (Callon, Barry and Slater 2002, p.293) but goes on to illustrates the central role of ICTs in these efforts.

As was shown, the formats of the five separate marketplaces had to be made compatible, but these formats do not only concern electronic data structures, network protocols, and messages, but also legal and regulatory arrangements, business practices, and payment mechanisms. In effect, five different market frames had to be subsumed into one and, as the research has shown, ICTs are fundamentally implicated in this process. The research shows how, in order to, as Callon suggests, "mobilize other places and ... connect them to the place where interactions are done" (Callon, Barry and Slater 2002, p.293), ICTs are not only important in terms of the mobilising and connecting, but also in terms of the reframing of interactions that is necessary for this mobilisation and connectivity to be made possible.

In the case of securities, this reframing started with the introduction of ICTs to local securities trading and settlement arrangements associated with dematerialisation that brought with it dramatic increases in the speed and reliability of transactions. Coupled with the emergence of a body of formal knowledge about the functioning of clearing and settlement arrangements and

their importance to both financial markets but also entire national economies (Group of Thirty 1988, 1990b, Committee on Payment and Settlement Systems 1992, 1995, 2000, 2001, Committee on Payment and Settlement Systems and Technical Committee of the International Organization of Securities Commissions 2001), this also brought about a degree of standardisation, codification, and clarification of the roles and competences of the entities involved in securities settlement and of the interrelations, processes, rules, regulations and practices that bound them together.

Through the coding of the settlement arrangements of a financial marketplace into an ICT-based platform and of securities into binary digits, a local market frame was expressed in an ICT vocabulary and rendered compatible with a wide range of ICT transformations and techniques that made possible – even easy – the conceptual mapping of diverse particular frames to one another and aided the establishment of comparisons, equivalences, and differences[140]. This rendered much more obvious how different local market frames might be made compatible with one another and what work was necessary to bring this compatibility about. It made it possible to see how different elements of the settlement systems could be taken apart and reassembled in a different way and new ones added so as to enable the building of a new common market frame while keeping in place those elements of the local arrangements that were jurisdictionally specific and necessary for the objects of exchange to maintain their properties. The links and relations that had to be put in place for an integration between the separate and different local market frames to be made possible became both more explicit but also calculable in terms of estimating the costs and risks that different courses of action might entail. It was then that the space, time, and cost reducing properties of ICTs posited by many transaction cost analyses of markets and ICTs could come into play and be judged, not on their own, but in combination with all the other elements that

[140] This was similar to Latour point in relation to the gains in compatibility, standardisation, and calculation that the soil scientists in the Amazonian forest attain as they move from the local materiality of the forest floor to a diagram of this setting that "reveals to us features that previously were invisible" by combining on a paper surface "very different sources that are blended through the intermediary of a homogeneous graphical language" and makes possible the modelling of the situation that "allows the imagining of new scenarios" (Latour 1999, p.66).

this interface between sociotechnical arrangements and market frames involved. As the research found, economies of scale and transactions cost reductions are a result – and a contested one at that – not an a priori assumption of the introduction of ICTs to financial marketplaces. They need to be produced and constructed, just like the ICTs themselves and it is not unthinkable that they may even fail to materialise.

A related finding regarding the role of ICTs in the setting studied is the way they facilitated the actual taking apart and re-assembling of existing market frames and already durable sociotechnical relationships. Just like all other sociotechnical objects and artefacts, computers, algorithms, databases, secure data communications networks, network protocols, electronic messages, parsers, electrons, transistors are also heterogeneous assemblies of human and non-human entities. But they have developed their own logics and grammar, rules, syntaxes, and modalities. As they have got progressively more 'black boxed', their articulation among themselves and with other sociotechncial assemblies has been facilitated and standardised. Similar to Latour's observations about the diagrams of the soil scientists in the Amazon forest allowing their research setting to be formatted in such a way that it could be operated on by geometry and its forms and tools (Latour 1999), once something – in this case securities – has been coded into binary digits, the resources of an entire ICT language and vocabulary can be deployed to deal with it and operate on it. A whole raft of techniques can be used to map, compare, convert, translate, encode, decode, transmit, receive and generally make possible its blending with very different things from other sociotechnical networks. It is this ability of ICTs to facilitate the linking of previously separate frames and sociotechnical networks, in short their connectivity in terms of frames, as much as in terms of places or interacting parties, that "reveals to us features that previously were invisible" (Latour 1999, p.65) and make possible the modelling of situations that "allows the imagining of new scenarios" (Latour 1999, p.66). In the process, a new aspect of reality is rendered explicit and in concrete form. As Latour writes in regard to

technologies in general, they are not just means to and end but "incite around them that whirlwind of new worlds" (Latour 2002, p.250)[141].

The final important output from this research regarding the conceptualisation of ICTs and their role in financial markets relates to the way the need for computational and algorithmic certainty demanded by digital electronic ICTs renders explicit facets of a setting that previously may have been obscure or treated elliptically.

As has been described in greater detail in the chapter presenting the research setting (but also in Appendix E describing the functionality of the CREST), at the heart of any ICT-based securities settlement platform there is always some kind of algorithm that receives matched settlement instructions for transactions that need to be concluded. It is the role of the algorithm to check the availability of all the resources specified in the transaction that need to pass between the counterparties and to position the transaction in some kind of sequence or queue of transactions that the algorithm then processes according to certain rules and procedures by transferring the resources to be exchanged between the accounts of the transacting parties. Transactions that for whatever reason do not settle are then re-entered into the algorithm for processing in the anticipation that as other transactions go through, the missing resources might have become available. This recycling of failing transactions is repeated until the transaction either eventually succeeds or some intervention stops it (e.g. an optimisation routine attempts to find links between failing transactions, or some kind of manual intervention takes place). The performance of a settlement system is generally judged by its ability to minimise the number of failed transactions that remain at the end of a certain period, to minimise the amount of external intervention that may require to deal with problems and exceptions, and the speed at which it deals with a certain number of transactions.

[141] As Moser and Law put it: "[People and things are] juxtaposed in ways that are generative and produce novelty. They are made, and, at the same time, and as part of the same process, they are thrust into a new context. Something is being made that was not there before" (Moser and Law 2006, p.67)

While even the pre-electronic settlement arrangements of securities markets can be seen as a kind of rules-based physical algorithmic arrangement, the volumes and speeds at which the electronic ICT-based platforms operate and the consequences of having to deal manually with exceptions and unforeseen situations mean that a much 'tighter' and 'harder' framing of interactions is necessary.

In the paper-based system predicated on the following of laws, rules, processes and even informal common practices, there were many more 'details' that could remain 'pending', giving more flexibility to the framing of interactions. This cannot be the case, at least to the same degree, with computer-based systems. It is not possible to include a line in the computer algorithm that says: "if X then, we will see, someone will give a call to the lawyers or the board". The algorithmic and computational certainty now demanded results in problems that previously may have not need to be dealt with beforehand and therefore not taken into account in the design of a settlement system, being rendered explicit and visible by virtue of the need for concrete and unambiguous responses from all entities involved. In this way, through the design and development of the new settlement platform, the stakes of the various actants become visible and attain a concrete shape. The settlement system designers, in effect, set in motion trials that act as tests of explicitness for the outside entities with which the system must interface. In this way, previously implicit or obscure features are rendered explicit.

This demand for explicitness does not only concern technical issues but can also act as an interrogation of political issues. While an elliptical notion of a single securities market for Europe may allow for many different interpretations and configurations to be imagined, a working system that demands precise and unambiguous responses from the people, institutions, devices, and systems around it is a different matter. This was vividly illustrated in the controversy presented in the research (pages 163-167) regarding the interface between the Euroclear Single Platform and the TARGET2 Euro payments system that ultimately reveals links between the development of the

Single Platform and rival conceptualisations of European financial integration and the role of central banks in these conceptualisations.

Through the resolution of these kind of trials of encountered in the research, both the new platform itself and the external structures it comes into contact with are put to the test. In the process, important questions that must be resolved and assumptions that have been built into the rival views of the world inscribed into the sociotechnical entities that have thus come into contact are rendered explicit and contestable. Before such trials these questions lacked a concrete form, in the same way as knowing there is a certain law, but not knowing what this law does in a specific case until that specific case is somehow triggered.

In the specific case of the Euroclear single settlement platform the thing being rendered explicit ultimately is European – but also wider – financial integration. What would have happened to the abstract concept of a Single Capital Market for Europe if the Euroclear ICT-inspired experiment had not taken place? A range of possibilities and potentialities were open, but this test, just like a test case in law, has acted as a concrete interrogation of this abstract and elliptic conceptualisation out of which, specific and material expressions of the outcome take shape that will, in turn, shape important future institutional and material arrangements, both in the European integration project and beyond. There might, for example, be valid alternatives to the politico-legal approaches to market (and political?) integration used so far in the building of an integrated Europe. Or a wider range of choices regarding the role of central banks in general and the European Central Bank in particular, beyond those articulated in the current EU arrangements.

It is out of such struggles and their eventual resolutions that important issues regarding the world we will live in are already being settled. From the ability of a legal person in one jurisdiction to own economic assets in another jurisdiction in exactly the same way, and with the same rights and obligations, as a legal person in the jurisdiction of those assets, flow many important questions:

- How would such a development affect the running of corporations?
- What would the effects of such a mobilisation of capital be on national economic policy and the abilities of governments to manage their economies?
- By rendering capital markets comparable, might there be a long-term gravitation of capital raising activities to a jurisdiction with the most favourable tax regime?
- What would the implications of resulting tax receipt declines in other countries be if such a development were to take place?
- Would the new integrated cross-border market made possible by the new settlement system be dominated by "international trading organizations, banks, and investment firms with billions of dollars of capital, and a trading rather than an agency business" (Chapman 1990)?
- What are the systemic implications of such potentially large flows of capital?
- Should these be regulated and if so by who?
- Is there a role for the European Central Bank?
- Is the "user owned, user operated" governance structure the most appropriate or should such a systemically important system be owned and operated by the central bank that also operates the payment system?
- Should these two systems be integrated or separate?
- Would this have implications and risks for the economy as a whole and the money in our pocket?

In the final analysis, what kind of capitalism we are likely to have to be part of in the future is going to be linked to the capital market arrangements that will be built into technologies such as the cross-border settlement system that has been studied here. The durability that such an entity acquires along the way as trials of strength with competing 'scripts' encountered get resolved and as the new system links-up with more, longer, and harder sociotechnical networks is likely to be considerable. Future reconfigurations or reforms of the resulting assemblage will be difficult once it is 'black boxed' and articulated with

powerful installed bases such as existing big pools of liquidity and large volumes of transactions start flowing through it.

That technologies (Winner 1980, 1993) and markets (Fligstein 1996, 1997, 2001) "have" politics is not a new claim. It is through understanding how and when these politics are 'put in' that the consequences of "what the introduction of new artifacts means for people's sense of self, for the texture of human communities, for qualities of everyday living, and for the broader distribution of power in society" (Winner 1993, p.368) can be grasped and addressed better. This research provided a concrete illustration of how important choices with significant future political and other implications are inscribed into a 'market device'. In so doing, it "restores to markets the political dimension that belongs to them and constitutes their organisation as an object of debate and questioning" (Callon and Muniesa 2005, p.1245). It is out of the development of new 'market devices' and their fitting together with existing ones, as illustrated in this research by the way the Euroclear cross-border settlement platform designers used ICTs to link up five separate existing legal frames governing the transfer of securities, that the kind of global financial marketplace described by Chapman (Chapman 1990, p.198) in the introduction will gradually come about. The heterogeneity of such 'market devices' means, however, that this will require as much social as ICT engineering. This is why, despite the capabilities of ICT far exceeding those assumed by Chapman in the introduction to this thesis (Chapman 1990, p.198), almost two decades later there is still no global financial marketplace that looks like the vision he conjures up.

Appendices

Appendix A: Licence for the use of Euroclear material

PTO ...

WEBSITE DATA ACCESS AND USE AGREEMENT

DATE: _____ 2006

PARTIES:

1. CRESTCo Limited, a limited company whose registered office is at 33 Cannon Street, London EC4M 5SB ("**CRESTCo**"); and

2. [ ] whose address is_____ ("**User**").

WHEREAS:

(A) CRESTCo is (i) the operator of a system for the electronic holding, and settlement of transfers of, securities and certain related transactions and in connection with the operation of such system obtains or generates certain information and (ii) the proprietor of the following website, www.crestco.co.uk.

(B) User wishes to use certain data available through the above website for [describe use] (the "**Publication**") and CRESTCo has agreed to grant a licence to User to access, use and reproduce certain data within the Publication on the following terms and conditions.

In exchange for the mutual promises set out herein, IT IS AGREED as follows:

1. DEFINITIONS AND INTERPRETATION

1.1 In this Agreement, unless the context otherwise requires, the following words and expressions shall have the following meanings:

Agreement	this agreement between the parties, including the Schedule;
Commencement Date	the commencement date of this Agreement, being _____;
CRESTCo Web Site	the web site located at URL www.crestco.co.uk, but excluding any areas of the website with restricted access rights;
Data	[describe information to be used].
IPR	copyrights, patents, utility models, trade marks, service marks, design rights (whether registered or unregistered), database rights, semiconductor topography rights, proprietary information rights and all other similar proprietary rights as may exist anywhere in the world in the CRESTCo Web Site, including the those parts of the CRESTCo Web Site hosting the Data.

1.2 In this Agreement:

1.2.1 clause headings are for convenience only and shall not constitute a part of this Agreement or affect the meaning or interpretation of this Agreement;

1.2.2 any reference to a notice is to a written notice.

2. TERM AND TERMINATION

2.1 This Agreement shall commence on the Commencement Date and shall continue indefinitely unless and until terminated (i) by either party by giving the other party no less than twenty (20) days prior written notice or (ii) otherwise pursuant to the provisions of this Clause.

2.2 This Agreement may be terminated immediately by either party if the other party commits a breach of this Agreement which is a breach capable of remedy and the defaulting party fails to remedy the same within fourteen (14) days after receiving written notice of the breach requiring it to be remedied or the breach is not capable of remedy.

2.3 CRESTCo may at any time terminate this Agreement immediately by giving notice in writing to User if:

2.3.1 CRESTCo is of the opinion that User's use of the Data or any associated IPR is, or may be, damaging or in any way detrimental to any of the Data, the IPR, the security or integrity of CRESTCo's systems and networks or to CRESTCo's reputation and goodwill in general; or

2.3.2 CRESTCo no longer has access to, or the right to provide, the Data or the CRESTCo Web Site.

2.4 On termination of this Agreement, User shall procure that the Data shall be removed from, and shall not be referred to in, any subsequent reissues or reprints of the Publication or any other related publication.

3. GRANT OF LICENCE

3.1 CRESTCo hereby grants to User a non-exclusive, non transferable, revocable worldwide, royalty-free licence to copy, use and publish the Data (or parts thereof) in the Publication, but not for any other purpose. The licence granted herein includes the right for User to make and store (in whole or in part) electronic or print copies of the material comprised within the Data.

3.2 User agrees to submit to CRESTCo for approval details of how the Data (or any part) is to be referred to within the Publication and shall procure that the Data (or any part) is not published without obtaining CRESTCo's prior written consent to such publication. User acknowledges and hereby agrees that the Data (or any part thereof) may only be included within the Publication on the following basis:

3.2.1 it shall be clearly stated that CRESTCo is the supplier of the Data;

3.2.2 CRESTCo's name or logo shall be published alongside the Data (together with a date of origin if relevant),

in each case in a manner approved by CRESTCo in writing. User shall be solely responsible for checking and ensuring that the Data (or any part) appearing within the Publication is accurate, complete and timely (based upon the information available on the CRESTCo Web Site) and not misleading in any way.

3.3 User agrees to be bound by the exclusions and disclaimers of liability set out on the CRESTCo Web Site in addition to the specific obligations set out in this Agreement.

4. CHARGES

There shall be no charge for the provision of the Data.

5. LIABILITY

5.1 User acknowledges and agrees that CRESTCo shall not be responsible for the availability or otherwise of the CRESTCo Web Site. CRESTCo does not give or make any guarantees, representations, undertakings or warranties (whether express or implied) of any kind as to (i) the accuracy or completeness of any information, data or material contained on the CRESTCo Web Site (including the Data) or (ii) the satisfactory quality, quantity, fitness for purpose or use of the Data or (iii) that access to or use of the Data is lawful in locations other than the United Kingdom.

5.2 User acknowledges and agrees that the Data has not been prepared to meet any particular requirements that User or any third party may have and is made available by CRESTCo on an "as is" basis.

5.3 Except in the case of death or personal injury arising as a result of the negligence of CRESTCo, CRESTCo excludes all liability for any losses, damages, costs, claims or expenses of any kind whatever (whether direct, indirect, special or consequential) arising out of or in connection with this Agreement or use of the Data as contemplated herein, including, but not limited to, any direct or indirect, incidental, special, punitive, exemplary or consequential losses or damages, whether arising from contract, equity, tort (including negligence or strict liability) or any other theory of liability. In no event shall CRESTCo be responsible for claims made by a third party against CRESTCo or User.

5.4 The exclusions and limitations of liability set out herein and on the CRESTCo Website constitute an essential part of this Agreement. User acknowledges and agrees that these exclusions and limitations are reasonable and that without such exclusions and limitations CRESTCo would not enter into this Agreement.

6. USE OF INTELLECTUAL PROPERTY

6.1 User shall have no rights in or to the Data except as set out in this Agreement. This Agreement does not constitute an assignment of any IPR of whatsoever nature by CRESTCo to User.

6.2 No usage of any CRESTCo logo or other mark shall be permitted without obtaining CRESTCo's prior written consent (subject to such conditions as CRESTCo may impose).

6.3 Without limiting the generality of the above, User shall not do or suffer to be done any act or thing which may adversely affect the rights of CRESTCo in and to any of the IPR or which might reduce the value of any of the IPR or the goodwill of CRESTCo in general.

7. NOTICES

7.1 Any notice or request required or permitted to be given or made under this Agreement shall be in writing. Any notice or request shall be deemed to be duly given or made when it shall have been delivered by hand or registered mail to the party to which it is required to be given or made at such party's address specified above. Any notice shall be deemed to have been served as follows:

7.1.1 if delivered by hand, at the time of the signature confirming receipt of delivery to the address of the recipient;

7.1.2 if sent by registered mail, two (2) business days after the date of posting.

8. ENTIRE AGREEMENT

This Agreement constitutes the entire and only agreement between the parties relating to the subject matter hereof and supersedes and extinguishes any previous drafts, discussions, terms and conditions, agreements, understandings, arrangements, representations, undertakings and warranties, whether oral or written, between the parties relating to the subject matter of this Agreement.

9. ASSIGNMENT AND SUB-CONTRACTING

User shall not assign, transfer, sub-contract, sub-let or otherwise dispose of any of its rights or obligations under this Agreement without the prior written consent of CRESTCo.

10. EXCLUSION OF THIRD PARTY RIGHTS

A person who is not a party to this Agreement shall have no rights under the Contracts (Rights of Third Parties) Act 1999 to enforce any term of this Agreement.

11. GOVERNING LAW

This Agreement shall be governed by and construed in accordance with English law and the Parties hereby submit to the exclusive jurisdiction of the English Courts.

IN WITNESS WHEREOF the parties have signed this Agreement on the date set out above.

Signed for and on behalf of **CRESTCo Ltd** by:	)))	.....
Name.....	)	Signature
Position.....	)	
Signed by [ ]	)	.....
		Signature

Appendix B: List of consultation and project documents used

Euroclear Settlement of Euronext-zone Securities (ESES)

- Update paper: Investment funds in ESES - Service description (October 2006)
- Update paper: Migration to ESES - Launch scenario (August 2006)
- Update paper: ESES Blueprint - Edition 5 (July 2006)
- Update paper: Transaction lifecycle in ESES - Service description (April 2006)
- Update paper: Reference data in ESES and migration of reference data from legacy systems to ESES - Service description (April 2006)
- Update paper: Physical securities handling in ESES for the Belgian and Dutch markets - Service description (April 2006)
- Update paper: Reorganisation events and transformations in ESES - Service description (March 2006)
- Update paper: Foreign securities in ESES - Service description (March 2006)
- Update paper: Settlement banks' reporting and control tools for Euro as from ESES - Service description (March 2006)
- Update paper: Market claims - Service description (February 2006)
- Update paper: Stock distributions - Service description (February 2006)
- Update paper: Mandatory cash distributions - Service description (August 2005)
- Consultation paper: Migration of data from RGV to ESES (July 2005)
- Consultation paper: Physical securities handling in ESES for the Belgian and Dutch markets (June 2005)
- Consultation paper: Foreign securities in ESES (June 2005)
- Consultation paper: Euro DVP settlement in central bank money - Settlement bank control tools (May 2005)
- Consultation paper: Reorganisation events and transformations in ESES (April 2005)
- Consultation paper: Transaction lifecycle in ESES (March 2005)
- Consultation paper: Euro DVP settlement in central bank money (February 2005)
- Consultation paper: Stock distributions and distributions with options (January 2005)
- Consultation paper: Market claims (January 2005)
- Consultation paper: Mandatory cash distributions (November 2004)

Early harmonisation and Single Gateway

- Update paper: Early Harmonisation and the Single Gateway - Service description (August 2006)

Common Communication Interface (CCI)

- Update paper: Common Communication Interface - Service Description (January 2006)
- Update paper: Common Communication Interface - Consultation response (January 2005)
- Consultation paper: Common Communication Interface (June 2004)

Single Platform

- Update paper: Single Platform Custody Blueprint - Edition 1 (November 2006)
- Update paper: Meeting services on the Single Platform - Service description (October 2006)
- Update paper: Securities accounts and payment structures on the Single Platform - Service description (October 2006)
- Update paper: Securities financing and settlement windows on the Single Platform - Service description (October 2006)
- Update paper: Primary market issuance and physical securities on the Single Platform - Service description (October 2006)
- Update paper: Transaction lifecycle on the Single Platform - Service description (September 2006)
- Update paper: Reorganisation events on the Single Platform (Part two) - Service description (August 2006)
- Update paper: Early Harmonisation and the Single Gateway - Service description (August 2006)
- Update paper: Securities reference data on the Single Platform - Service description (July 2006)
- Update paper: Reorganisation events on the Single Platform (Part one) - Service description (July 2006)
- Consultation paper: A market discipline regime on the Single Platform (May 2006)
- Consultation paper: Transaction reporting on the Single Platform (May 2006)
- Consultation paper: Miscellaneous items on the Single Platform (May 2006)
- Update paper: Settlement banks' reporting and control tools for Euro as from ESES - Service description (March 2006)
- Update paper: Market claims - Service description (February 2006)
- Consultation paper: Meeting services on the Single Platform (February 2006)
- Update paper: Stock distributions - Service description (February 2006)

- Consultation paper: Euro DVP settlement in central bank money on the Single Platform - further harmonisation for the payment structure (December 2005)
- Consultation paper: Sterling DVP settlement in central bank money (December 2005)
- Consultation paper: Reorganisation events on the Single Platform (Part two) and open transaction management (November 2005)
- Consultation paper: Securities reference data on the Single Platform (November 2005)
- Consultation paper: Primary market issuance and physical securities on the Single Platform (October 2005)
- Consultation paper: Securities financing and settlement windows on the Single Platform (October 2005)
- Update paper: Mandatory cash distributions - Service description (August 2005)
- Consultation paper: Reorganisation events on the Single Platform (Part one) (July 2005)
- Consultation paper: Transaction lifecycle on the Single Platform (July 2005)
- Consultation paper: Structure of securities accounts on the single platform (July 2005)
- Consultation paper: Euro DVP settlement in central bank money (February 2005)
- Consultation paper: Stock distributions and distributions with options (January 2005)
- Consultation paper: Market claims (January 2005)
- Consultation paper: Mandatory cash distributions (November 2004)

Convergence - Business Model and Harmonisation Newsletter

- Convergence - Issue 6 (December 2006)
- Convergence - Issue 5 (July 2006)
- Convergence - Issue 4 (February 2006)
- Convergence - Issue 3 (June 2005)
- Convergence - Issue 2 (January 2005)
- Convergence - Issue 1 (October 2004)

Overview and background

- Business Model and Harmonisation (Euroclear website)
- Update paper: Single platform implementation plan (March 2005)
- Consultation paper: Harmonisation Fundamentals (June 2004)
- Consultation paper: Harmonisation Preliminary Proposals (June 2004)
- Update paper: Business plan for Systems Consolidation (November 2003)
- Update paper: Inventory of harmonisation needs - edition 1 (October 2003)

- Update paper: The Business Model and Harmonisation consultation responses - Edition 1 (September 2003)
- Overview and planning (September 2003)
- Consultation paper: Harmonisation Roadmap (April 2003)
- Consultation paper: The Euroclear Business Model, further details - Edition 1 (April 2003)
- Brochure: CREST & Euroclear - Delivering a domestic market for Europe (September 2002)
- Delivering a domestic market for Europe - Business Model (July 2002)

Appendix C: The sociotechnical character of securities: the example of stocks and shares in the UK

The trading of stocks and shares is premised on the historical institutional innovation of the joint-stock company or, as it is know today in the UK, a company limited by shares. This allowed the development of corporate entities as separate legal persons. Ownership, control, and governance is through the holding of shares, traditionally taking the form of paper share certificates, entitling the holder to a particular fraction of the company, its assets, profits, and decision-making powers.

At the formation of the company the initial capital of the company, which may even be a small nominal amount, is divided up into a certain number of units, the shares, which are then issued to the initial investors in exchange for the amount of capital they have contributed to the company. The number of shares they receive will reflect the proportion of the initial contribution they make to the setting up the company[142].

The face value of the individual original shares, which will be written on the share certificates, will be equal to the starting capital of the company divided by the total number of shares issued. As the company grows and starts to make profits, the actual exchange value of the shares will fluctuate to reflect this, but the face value of the share certificates will remain unchanged.

Share certificates can either be numbered and then registered under the name of a particular shareholder, or can be anonymous with the property and governance rights conferred by them being dependent entirely on physical possession of the certificates. These are known as 'bearer certificates'.

In the case of registered shares, a register of shareholders and the numbers of the certificates they have been allocated is kept by the company's secretary and

[142] This share capital does not necessarily reflect the actual market value of the company.

amended accordingly if shares are transferred or the shareholdings are somehow altered for whatever reason. If the original shareholders decide to bring in a new investor or participate in a merger or want to sell the company, transfers and sales of shares are likely to be involved and this would be reflected in the share register of the company, with existing numbered shares being entered under the name of any new investors that join the group of existing shareholders or new shares added to the register if the share capital is altered [143].

While with smaller privately held companies such changes are not usually very frequent and complex, in the case of what are known as public companies, or PLCs in the UK, whose shares can be made available to the general public, such transfers, exchanges, and trading can take place on a much larger scale and frequency[144]. Because in such a case the volume and frequency of share transfers involved can become very large, it would become a full-time job for the company secretary and probably a staff of a few administrators to record and effect the accompanying entries to the company's share register. In the case of PLCs whose shares were traded on a stock exchange, this task became outsourced to external Registrars, operated by the large banks or other specialist financial and corporate services companies and entrusted to effect the necessary processes for the maintenance of an up-to-date share register, communications with shareholders, disbursement of dividends, etc.

Before the introduction of CREST in the UK, these Registrars operated a distributed share registry system for the shares of companies traded on the stock exchange, but in other jurisdictions, a central registry or depository of shares eligible for trading on the stock market was instituted, with certificates available for trading on the stock exchange 'immobilised' in such Central Securities Depositories (CSDs) and simply moved from the account of one

[143] The principal governing legislation for stock transfer forms is the Stock Transfer Act 1963. In the UK, until the introduction of the CREST ICT-based settlement system to in 1996, the Stock Transfer Form sent to a company's Registrar represented the only means of transferring legal title in the UK and it is still used today for transfers of the remaining paper titles for certificated stock still in circulation.

[144] The PLC, in the case of the UK, is also the form of company that can have its shares traded on an organised marketplace such as a stock exchange.

member to that of another as a trade took place. This is known as 'book entry' transfer. As the name suggests, the transfer is effected through an amendment in the central registry of shares, or 'book', by changing the name of the holder in the registry or 'book' from that of the seller to that of the buyer, thus amending the 'book entry' for that share certificate. When the shares have also been 'dematerialised', that is, structured electronic data entries in a recognised and authorised computer system have replaced paper certificates as titles to ownership, the 'book' is replaced by a database with tables for members and tables for shares, with the field for the owner of a certain share being changed in order to reflect the transfer of ownership.

The conclusion of a transfer of securities from a seller to a buyer through a 'book entry' at a CSD is effected when what is known as Delivery versus Payment (DvP) takes place (i.e. the simultaneous movement of the titles being traded from the account of the seller to that of the buyer and the agreed payment from the account of the buyer to that of the seller)[145].

In the UK, until the introduction of the CREST settlement system in the mid-90s, there was no CSD, with transfer instructions having to be sent to the individual Registrars responsible for the share register of a particular company to amend the registry entries for that company as transactions in its shares took place. Even when Talisman, the first electronic system for the processing of trades, was adopted by the London Stock Exchange in 1979, this decentralised process was maintained, with the London Stock Exchange setting up a special company with an account with each and every Registrar of companies whose shares were traded on the stock exchange[146].

---

[145] While this appears, in theory, a straightforward process, achieving finality and incontestability in a transaction is far from simple in practice. This is especially the case when one considers the large amounts and volumes of assets being transacting by securities market participants trying to squeeze the most out of their working capital by limiting as far as possible the time these assets remain idle in the system.

[146] With the Talisman system, all purchases and sales of shares on the Stock Exchange were processed centrally during the day, with the details of the transactions passed back to the Registers who would then make the appropriate amendments to the relevant share registers they maintained and arrange for the paper certificates to be moved from account to account, via the account of the special Stock exchange entity. While the Talisman computer generated all

Appendix D: The securities transaction lifecycle

Matching, positioning, sequencing, and finality

In a typical securities transaction, once a trade is concluded, for example on a stock exchange, a matching system will seek to reconcile, using some kind of algorithm, the instructions submitted by the counterparties on either side of the trade. If a match is found this indicates that there is agreement between the two parties on the terms of the trade. Once such a match has been achieved and the two potential transacting parties have been brought together, a confirmation is then sent to the two sides, either directly or through their brokers.

Once this confirmation has been accepted by the two parties, they can now be considered as counterparties to the transaction and the details of the trade, similar in content to the confirmation, are passed on from the matching system to the settlement processor for the positioning of the agreed resources (e.g. securities and cash) and the sequencing of the necessary transfers in such a way that a definitive and irreversible transfer of ownership between the transacting parties and the extinguishing of any obligations relating to this specific transaction is achieved. The matching, positioning and sequencing of transactions may take place within the corporate and operational structures of the stock exchange or in a separate entity. In general, however, these parts of a transaction are generally considered to be part of the settlement phase of the transaction.

At its most basic, the role of the settlement provider is to make sure that the details for the completion of the transaction are clearly and unambiguously defined and the various links necessary to process and conclude the transaction are in place. This way the obligations of the two counterparties are structured and organised and made ready for processing. Any discrepancies have to be

---

the relevant paperwork and calculated the tax due and stamp duty, it still required the eventual physical transfer of paper certificates and contract notes. As transaction volumes climbed rapidly with the liberalisation of stock exchange trading in the 1980s ('Big Bang'), the system began to clog-up with paperwork.

identified and resolved at this stage, before a trade can be processed further and it is not uncommon for errors and transaction failures to occur.

Netting and central counterparties

In order to reduce the amount of actual payments and security transfers that need to be processed and thus reduce the risks of errors, transaction failures, and defaults, all of which increase the overall risk to the system, various forms of netting – or offsetting – of trades have increasingly been adopted. Netting can take a variety of forms, but in principle involves the cancelling out of identical obligations among counterparties.

During an entire trading day it is likely that a particular security might be bought and sold a number of times in different quantities and at different prices and in different directions between two transacting sides. Rather than process all these transactions independently, netting arrangements add up all the transactions during the day, many of which might actually cancel out. This way, at the end of the trading day only any outstanding balance needs to be processed all the way through to final settlement when a payment is made in exchange for the securities that remain outstanding after netting.

In an arrangement with more than two participants the netting processes becomes much more complex. In such a case, multilateral rather than bilateral netting is likely to take place. In such an arrangement the clearinghouse interposes itself between the counterparties as a buyer for every seller and seller to every buyer taking on the role of Central Counter Party (CCP)[147]. This allows the clearinghouse to, in effect, become a pool consolidating all the payments and securities being exchanged by the counterparties, absorbing the securities being sold and undertaking to deliver the securities being bought at the end of the trading day. As soon as a transaction enters the CCP it becomes binding on the counterparties. The CCP is therefore assuming no risk itself as it has a buyer committed to the purchase of every security it buys at the price it

[147] In the case of the UK securities market, the central counterparty and the settlement system provide the demarcation between the clearing and settlement functionalities. London Clearing House (LCH) acts as a CCP, while CRESTCo, through its operation of CREST, acts as a CSD.

bought it for. By interposing itself between the transacting parties, however, and introducing a time delay between when a trade is submitted and when it is cleared, the CCP is able to have a market-wide view of all trades between all counterparties and thus can offset between incoming and outgoing elements of a transaction involving a particular security, regardless of counterparty.

The following illustration might help make the multilatteral netting clearer. Assuming there are four different counterparties [A, B, C, D] trading one particular security through a cleasringhouse that is operating as a central counterparty. During one particular trading day, B acquires 20 securities from D, D acquires 10 securities from A, C acquires 40 securities from B, and C acquires 5 securities from D. Although as far as the counterparties are concerned the trades are going through the clearinghouse from one to the other, from the perspective of the clearinghouse they appear as separate transactions of securities coming in and going out. The transaction between the two counterparties is decomposed into two parts; it becomes, in effect, two transactions between each counterparty and the clearinghouse. In this way, the clearinghouse can net the trades, cancelling out, on paper, the securities put into and taken out of the market-wide pool it represents by each counterparty, with accounts being debited and credited. In the example given, counterparty B has put in 40 securities and taken out 20, D has put in 25 and taken out 10, while A has put in 10 and C taken out 45. In net terms, D has a credit of 15, A, a credit of 10, and B 20, while C has a debit of 45. In terms of actual rather than paper trades that will settle any outstanding actual obligations, C will have to pay the clearinghouse the amount needed in order to receive the remaining 45 securities it has acquired, while D, A, and B will be paid for the net number of securities they need to deliver to the clearinghouse. With the central counterparty arrangements the total number of actual securities that need to be transferred at the end of the trading day is 45 rather than 75 if the trades were not netted. Obviously, as the number of counterparties and trades increases, the efficiency gains of netting become more pronounced. Following the same logic as that used in the netting of the securities movements, cash amounts that need to be transferred in terms of payments are also similarly reduced.

Central Securities Depositories

Whether a clearing entity interposes itself as a central counterparty or not, at the point in the trade when actual securities and their ownership have to be transferred in exchange for a payment, the central securities depository (CSD) will come into play. CSDs once again have their roots in the physical world, having provided the venue at which the physical securities certificates were stored and in which they would be physically moved from the account of one counterparty to that of another upon the completion of a transaction and the confirmation of the delivery of the payment by the opposing party in the trade.

CSDs are linked particularly with securities trading because of the property rights associated with them and the role of the CSDs as an interface with the legal and fiscal regimes in particular jurisdictions. The dematerialisation of certificates has resulted in the physical transfer of securities being replaced by the transfer of records, first on legers as 'book entries' and then as electronic entries in databases.

Whatever the practicalities of the transfer, all the necessary data and linkages should be correct and in place once the particulars of a trade are passed on to the CSD from the CCP. The final and irrevocable delivery versus payment (DvP) takes place at the CSD with the transfer of securities into the CSD account of the counterparty (or that of an agent) acquiring the securities as soon as the payment made in exchange for the acquisition is made through the bank payment system to the account of the seller or an agent acting for the seller. It is obviously imperative that even the slightest time discrepancy between the payment and delivery is avoided in order to reduce the likelihood that some payment default may occur when the securities have already been delivered (Committee on Payment and Settlement Systems 1992).

At first glance, settlement might appear as a straight forward process, but the increasing use of securities for lending and as collateral for payments and covering obligations means that the role of the CSDs is far from simple (Committee on Payment and Settlement Systems 1995).

Custody and safekeeping

Although the basic elements of a securities trade are described above, there are some additional intermediation services, often supplied by external service providers that contribute some additional functionalities.

One group of such intermediaries are the custodians or custody banks. The role of the custodian is to manage many of the logistical elements associated with the trading and holding of securities by investors, provide consolidated reporting of holdings and what is known as safekeeping services, ensuring that dividends or interest due are received, and the ultimate beneficiary is informed about corporate actions, new share issues, share splits etc. They aim to extract large economies of scale from the operation of their CSD accounts and their links and interfaces with clearinghouses, using them to process the transactions of clients. They are also likely to have accounts with the central banks, thus also providing the banking facilities for the payment leg of the DvP process. As such, they can provide a one-stop-shop for settlement services to investors who, once again, may not be able to justify their outlay for all these arrangements individually. Custodians can offer access through their internal arrangements to many CSDs and their ability to aggregate the business of many clients makes them big users of CSDs and clearing entities. Global custodians, as the name suggests, are those that offer such services in many marketplaces and jurisdictions, either through their own corporate presence, or by engaging the services of other custodians with a presence in a particular marketplace. It is through these type of arrangements and the concatenations of ownership that they result in, that trading of securities across marketplaces and jurisdictions has been possible up to now (Committee on Payment and Settlement Systems 1995, Benjamin 1996, 1998, 2000, Giovannini Group 2001, Schwarcz and Benjamin 2002, de Carvalho 2004).

Appendix E: The introduction of ICTs to the settlement of UK securities transactions

In the pre-computer world, the UK settlement system was much more of an ad hoc arrangement depending on a distributed interpretation of the legal and regulatory provisions for the transfer of titles articulated with certain specified material entities such as the Stock Transfer Form and other financial sociotechnical systems such as the payment and banking systems. In the post-CREST word the framing of the market by the settlement system has become tighter. Settlement system participants have much more precise roles and there is much less opportunity for ad hoc arrangements and procedural and organisational interpretations of the laws, rules and regulations governing securities exchanges.

As financial markets became increasingly institutionalised, face-to-face exchanges were replaced by the flow of written and verbal instructions among market participants. Now these instructions take the form of electronic messages circulating among computer systems via secure telecommunications networks. As the exchange of physical certificates for cash has been replaced by non-physical exchanges, the trading of securities has become an almost purely informational and abstract process.

The dematerialisation of certificates and the introduction of electronic payments have been central to this development. As a result, there has been a big increase in the volumes of transactions that can be processed and the speed at which they are processed and securities settlement has become much more tightly intertwined operationally with other important automated electronic systems that comprise the broader financial system of advanced economies.

CREST: inscribing a geography of responsibilities into an ICT platform

Tracing the development an adoption in the UK of the CREST ICT-based settlement platform for securities transaction it is possible to see how, through

the assembling of human and material entities into a durable whole, a specific and materially expressed exchange architecture that frames securities transactions in a particular jurisdiction was put in place.

The resulting architecture specifies the roles and competencies of the various market participants, relates these participants to specific objects, processes and functionalities in specific ways, and also stipulates the entry and exit points through which the 'inside' of the system interacts with entities on the 'outside'.

The origins of the CREST system illustrate how inscribing a geography of market roles and responsibilities into an ICT-based settlement system involves not only the assembling of the software and hardware to be used, but also an intricate weaving together of ICTs with legal and regulatory provisions, organisational and corporate forms and structures, and the existing market practices, cultures and traditions that characterise individual markets.

It is through a parallel process of legislative and ICT design that the CREST platform at the centre of the UK ICT-based settlement system attained the particular legal status through which the ownership of securities and financial titles could be defined and transferred by electronic data entries on a "recognised system" that imposes rules and regulations on its users/members.

The assembling of CREST

A key event in the decision to move to an ICT-based settlement system in the UK was the stock market crash of 1987 when settlement backlogs became unmanageable on the London market. It became apparent that there was an urgent need for the London Stock Exchange to move to a completely electronic trading infrastructure if the London market was to maintain its leading position in the globalising financial services industry[148].

[148] Such are the pressures on participants in the financial system to maximise the use of their assets that the balance between assets and liability is taken to the outer limits of what is manageable for a certain level of risk. Under such circumstances, even a small delay in processing a trade or a payment can result in liquidity pressures that are transmitted throughout the system. For a detailed account of the risks associated with securities settlement see (Committee on Payment and Settlement Systems 1992).

When it was decided that a move to the electronic trading of shares was need, legal provision for what was termed the 'dematerialisation' of securities certificates had to be made. This would need to be done through an amendment to the Companies Act [149]. Through this amendment, the property rights conferred through paper share certificates would be extended to electronic entities in the database(s) of the proposed system(s) and would thus be defined in law as equivalent to paper forms of titles (Smith 1996)[150].

It was in the Uncertified Securities Regulations (USRs), the legislation passed in 1995 to amend the Companies Act in order to allow for the 'dematerialisation' of share certificates, that the specification of the settlement system for the trading of shares on the London Stock Exchange was arrived at, leading to the development and adoption of the CREST system that is used to this day and that will be eventually absorbed into the Euroclear cross-border settlement system being studied in this research[151].

The new ICT-based settlement system was the solution developed as a way of making possible the electronic holding and transfer of shares traded on the London Stock Exchange (LSE), eliminating the need for stock transfer forms and certificates in transactions and thus speeding up the settlement process and reducing certain risks involved in this process.

After a brief period of parallel operation, CREST eventually replaced the still predominantly paper-based Talisman system developed and run by the LSE,

---

[149] According to the CREST "Domestic Legal Framework" manual, "before the introduction of CREST, the legal requirements governing the transfer of shares in Great Britain were primarily contained within the Companies Act 1985 and the constitutional documents of issuers" (CRESTCo 2002a).

[150] Although in practice only one "relevant system", CREST, has been approved under the USRs that amended the 1985 Companies Act in order to allow for dematerialised securities certificates, the legislation does not provide a legal monopoly to a certain operator and its system. In theory, there could be more than one such system as there is nothing, in law, preventing an alternative operator from applying for approval for some other settlement platform or system, as long as it met the specifications laid out in the legislation.

[151] The Uncertificated Securities Regulations of 1995 were made under the powers conferred on the Treasury by Section 207 of the Companies Act of 1989 to make regulations "to enable title to securities to be evidenced and transferred without a written instrument" (CRESTCo 2002a). Any regulations made under the provisions outlined above still required the affirmative resolution of both Houses of Parliament It was through the passing of these regulations that the new statutory framework within which the CREST system operates was created.

but CREST itself was designed to allow for the holding and transfer of paper certificates as well as those in electronic form.

The design and development of CREST lasted three years and took place in the shadow of the spectacular failure of the development of a previous proposed replacement for Talisman known as Taurus [152].

CREST went live on 15 July 1996, having gained approval on 11 July 1996 from the Securities Investment Board (SIB)[153] as conforming to the legal requirements for such a system stipulated in the revised Companies and Financial Services Acts, amended specifically through the USRs for the purpose of developing such an electronic settlement system.

The role of the Bank of England

The Bank of England (BoE) took a leading role in the decision to push for a system to replace Talisman that would make possible the electronic holding and transfer of shares. It also had a significant input in the way the design and development of this new system was undertaken (Interview D 2006).

In addition to its own knowledge of settlement issues derived from its in-house pool of market infrastructure expertise and participation in international industry forums and bodies concerned with best practices and standards (e.g.. BIS), the BoE was also seen as being in a position to draw from its own experience of running the settlement system for the trading of Gilts (government bonds), the Central Gilts Office (Smith 1996, Interview D 2006).

Insistence on the need for a new settlement system for the LSE came as a result of pressures and concerns from the government, certain sections of the market itself, and regulators regarding the risks, inefficiencies, and limitations inherent in the paper-based system and their impact on the position of the UK and London as leading global financial centres (Interview D 2006).

---

[152] Accounts of the Taurus failure are provided in (Drummond 1996, 1998). For comparisons between the approaches taken in the development of Taurus and CREST see (Currie 1997, Currie and Willcocks 1998).

[153] The SIB is now part of the Financial Services Authority (FSA).

The new system was seen as imperative if the London market was to be in a position to adopt what were seen as the minimum requirements of international best practice in the field of securities settlement as laid out by international expert bodies such as the Bank of International Settlement (BIS) (Committee on Payment and Settlement Systems 1992, 1995, 2000, 2001, Committee on Payment and Settlement Systems and Technical Committee of the International Organization of Securities Commissions 2001) and the so-called 'Group of 30' (Group of Thirty 1988, 1990b, 2003).

These minimum requirements were:

- Adoption of an accepted Delivery versus Payment (DvP) process
- 3-day settlement cycle
- Dematerialisation of securities

The first step from the BoE in the development of what would become the CREST system was to set-up a taskforce on securities settlement. This would examine all issues around the settlement of securities in the light of the collapse of the Taurus project in March 1993 that had been initiated and run by the London Stock Exchange[154].

The first output of the taskforce was a report delivered in June 1993 that stressed that the design of the new system should aim for:

- Simplicity
- Stability
- Avoiding "design creep" through the adding of new features during development
- Keeping the unavoidable need for legislative changes to a minimum

[154] Taurus had been abandoned as "fatally flawed" after it became irrecoverably over budget and with few if any deliverables ever achieved in line with the project timetable and many components of the proposed system not even designed when other parts were about to go into testing (Currie 1997, Interview D 2006).

CRESTCo and the ownership and governance of CREST

CRESTCo Ltd was the company set up to own and operate the CREST system. It was a private limited company incorporated in England and Wales and was to operate independently of any public authority, including the Bank of England, under whose auspices the company was first established as part of the development of the CREST system.

Its shareholder base included retail and corporate brokers, market principals, banks, custodians, registrars, the London and Irish Stock Exchanges and the virt-x cross-border market. It was, in effect, a type of users' cooperative, making limited fixed returns for its shareholders. This was designed to guard against the risk of CRESTCo exploiting any monopoly position to the detriment of its users and there were also provisions that guarded against the risk of domination by any single shareholder or group of shareholders (Interview D 2006). As CRESTCo is not able to increase dividends to shareholders or to accumulate excessive reserves, any operating surplus above that required to fund future development must be returned to users as a rebate or be reflected in tariff reductions.

Ownership of CRESTCo shares is restricted to entities that use the CREST system such as members or users, settlement banks, registrars and investment exchanges for which CRESTCo provides settlement services. Issuers of securities transferred through CREST are not, however, eligible to be shareholders.

The limits on the concentration of shareholdings ensure that no individual group of companies may hold more than 10% of the issued shares and no sector of the industry may hold more than 30% of the issued shares. To this end there has always been a biennial re-balancing exercise, which enabled the shareholder base to be adjusted to reflect actual usage of the system [155].

[155] By 2002 its ownership was shared by approximately 100 financial institutions representing a broad cross-section of the securities industry.

There is no requirement that all CREST participants be shareholders in CRESTCo.

The co-production of legislation and ICTs in the development of CREST

While keeping legislation to a minimum, due to the nature of titles to property such as shares, it was impossible to move to the 'dematerialisation' of share certificates without changes in legislation and regulations. This was done primarily through an amendment to the Companies Act in order to institute the vesting of property rights through electronic entries in a specifically designed, designated, authorised and licensed or approved computer system, the specification of which was laid down in the legislation as was the process through which a proposed system and system operator would be approved and mandated.

Smith writes about this:

> "The system provides for legal ownership of securities to be transferred electronically without a written instrument of transfer. This innovation gave rise to new legal concepts, which called for new legislation to spell-out the requirements for a system to transfer legal title electronically, taking into account the need to protect investors."[156]

The amendment to the Companies Act needed was passed in December 1995 under the title of The Uncertificated Securities Regulations and were developed by the SIB, the Treasury, and the Department for Trade and Industry (DTI), in consultation with CRESTCo, the developer and potential operator of the new system. Under the same regulations, the Treasury delegated to the SIB its powers to approve and oversee the "operation of systems to settle and transfer stock ownership electronically". Under this approach, CRESTCo, while working together with the SIB, the DTI, and the Treasury on the regulations that would bring the new system into existence, still had to receive approval before becoming what was known in the new regulations as an "operator of a relevant system" (Smith 1996).

[156] In (Smith 1996, p.52)

With the passing by Parliament of the USRs and the introduction of CREST and dematerialised holdings, a new mechanism for transferring legal title was introduced.

The USRs permitted legal title to be transferred via the acceptance – by the CREST platform – of a Properly Authenticated Dematerialised Instruction (PADI)[157].

The legal framework, however, supported – and still supports – two mechanisms for the holding and transfer of corporate securities:

- Through CREST, as the Operator of a relevant system under the Uncertificated Securities Regulations (URSs) 1995, that were made under s207 of the Companies Act 1989.
- Through the registration of a Stock Transfer Form signed by the transferor.

As far as CREST in concerned, only a CREST 'User' can input a CREST message and generate a PADI[158]. It is up to the security and authentication provisions of the system to ensure that all messages:

- Can be clearly identified as coming from a user's gateway
- Have not been tampered with en route
- Will not be lost in transit
- Can only be presented once

[157] All messages (PADIs) sent from a CREST user to the CREST system are sent over one of two private networks (currently, SWIFT and BT Syntegra Radianz).
[158] The term 'User' has a very precise meaning in the CREST system and its logical structure. A 'user' is any legal person, individual or corporate entity, with permission to enter instructions to the CREST system through a 'Gateway' computer device supplied and certified by CRESTCo and which provides hardware-based authentication and encryption of the resulting communications. A 'Participant', on the other hand, is defined as any legal entity that transacts over the CREST system. If a 'Participant' is also a 'user' then the necessary inputting of the instructions necessary for a certain transaction t take place can be done directly. If not, a 'Participant' has to engage the services of a 'User' for the purposes of communicating transaction instructions to the CREST platform.

In the current UK legal environment the Stock Transfer Form and the PADI represent the only mechanisms for initiating the transfer of legal title. Any alternative dematerialisation model in the UK would need to work within the legal constraints imposed by these two mechanisms.

The importance accorded in the design of CREST to the co-development of the necessary institutional and ICT arrangements can be gauged from comments from the SIB regarding the approval process for the system and how it depended "as much on the contractual arrangements among all the participants in the system as on the technical merits and adequacy of the computer and telecommunications equipment and devices"[159].

The requirements for the CREST system laid out in the new Uncertificated Securities Regulations (UCRs) can be summarised as follows. The system should:

- Use and respond to a common set of electronic messages from members regarding the movement of stock between accounts;
- Provide the electronic authentication of the messages;
- Compare the instructions inputted by buyers and sellers;
- Provide for the secure storing of correctly matched instructions;
- Check for the availability of stock and cash in the transacting members' accounts on settlement day;

[159] For example, the legal framework in relation to BoE RTGS payments is governed by the combination of the CREST Terms and Conditions (and comparable agreements entered into by other participant types), the Settlement Bank Agreement, the relevant RTGS Payment Agreement for each RTGS currency, other agreements between settlement banks and the Bank of England, and the individual contracts between RTGS settlement banks and their customers. These arrangements provide for the discharge of a payment obligation owed by one member (or the person on whose behalf or with whose consent he is acting) to another member by reason of the CREST settlement and its simultaneous replacement by a settlement bank payment obligation due from the paying member's RTGS settlement bank to the payee member's RTGS settlement bank. Simultaneously, the settlement bank payment obligations will be extinguished by means of an irrevocable undertaking by the Bank of England to credit an amount equal to the buyer's payment to the RTGS CREST settlement account group of the seller's settlement bank (and to debit the corresponding RTGS CREST settlement account group of the buyer's settlement bank). The irrevocable nature of the Bank of England's undertaking is sufficient to complete payment between the settlement banks even though it precedes actual debit/credit to the RTGS CREST settlement account groups (CRESTCo 2005).

- Move simultaneously stock and funds among the accounts of sellers and buyers in a transaction;
- Enable the borrowing and lending of stock and cash in order to provide the necessary liquidity for the risk-free and efficient operation of the market;
- Update/notify the traded stock's registrar;
- Provide for the transfer of 'certificated' shareholdings for investors wishing to retain shares in paper form;
- Maintain records of dematerialised shareholdings;
- Handle cash distributions, dividends and other stock events;
- Provide for the reporting of transactions to the relevant exchange;
- Account for stamp duty and any other tax obligations to the fiscal authorities.
- Defining the roles of system participants
- The key participants in the CREST system were defined as being:
- Members (market-makers, custodians, investors)
- Sponsors (Intermediaries for transactions of non-members or members with no direct connection)
- Registrars (Maintain and update company/issuer share registers upon receipt of instructions from the system or in the exchange of shares in a take-over or issue of new shares in a rights-issue. The Registrar is obliged to commit to the share register within two hours of receipt of electronic notification any valid share transfer).
- Payment Banks (Respond to instructions regarding the amounts payable by member-clients engaged in transactions with net outstanding payments settled at the end of the trading day under what is known as an 'assured payments agreement' between themselves and CRESTCo).

The approval process

The ICT system that was eventually approved by the SIB as conforming to the new legislation governing share transfers was CREST as proposed and developed by the CRESTCo consortium.

Central to the SIBs approval of CRESTCo and its system was "whether the system would work satisfactorily". The USRs were very specific as to the overall performance of the system and the functions that it had to be able to fulfil and it had been down to CRESTCo to translate these requirements into the relevant computer programmes, hardware, systems manuals, procedures, rules, contracts, and agreements.

According to the SIB, of central importance in the approval process were the procedures in place for the authentication and security of the data and messages used by the system and for the monitoring of the network performance of the two subcontractors (Smith 1996).

The secure maintenance of adequate records for long periods of time and the ability to handle large volumes of data without impairment in terms of speed and performance were also of importance, as were procedures for the notification and correction or resolution of errors and failed transactions (Smith 1996) [160].

The SIB also sought assurances that CRESTCo had in place adequate arrangements for the enforcing of its own rules vis-à-vis members, even though CRESTCo was pressing for its role to be seen as "a service, not a regulator" and sought to minimise the use of rules. This subsequently changed, with CRESTCo eventually making great play of its role as an enforcer of market integrity through what it refers to as its "Settlement Discipline regime" that aims to ensure that "the sustained effort made by the majority of firms to improve their matching and settlement performance is not undermined by the actions of a minority: a few 'free rider' firms might fail to improve their

[160] The SIB was also particularly interested, both during the design of the system and the subsequent approval procedure, in how the system accommodated particular practices found in the London market. Such market practices related to, for example, the roles that market participants such as registrars had historically in the London market and how issues such as termination of membership, withdrawal of securities from the system, methods of record-keeping and so on were treated. The failure to pay attention to such concerns in the development of Taurus was seen as having been an important contributing factor to the failure of that initiative, based as it had been on an attempted 'localisation' of Vista, a US database designed to comply with the regulations and market reality of the US and which its is said needed at least a 70% rework to be able to operate in the London market setting (Smith 1996, Interview D 2006).

processes and standards, and thus impose costs on the majority" (Euroclear 2005a, p.5).

> "Such costs can arise for the firm which is not at fault since it has unmatched or unsettled transactions to monitor, and it will incur clerical costs in chasing its counterparty for corrective action. CRESTCo runs the regime on behalf of the market. It consists of standards relating to matching and settlement, and sanctions for breaches of those standards. CRESTCo runs a similar regime in relation to registrars' standards of timeliness and accuracy, but in this case the regime is mandated by CRESTCo as part of assuring the Financial Services Authority (FSA) that the overall system approved under English law (comprising the core CREST system, its interaction with registrars, and the electronic networks by which CRESTCo and its customers and registrars interact) meets specified standards."[161]

Attention in the approval process was also focused on the agreements between members, CRESTCo, the payment banks, and the network providers and how such agreements would ensure that CREST, charged with providing a vital service to a recognised financial Exchange, would ensure that an Exchange would be in a position to satisfy regulators about meeting its own obligations under the Financial Services Act. Similar issues were of concern regarding the relationships between CRESTCo and Liffe and Tradepoint and LCH (Smith 1996, p.55).

> "[It was necessary to know in advance], how the procedures for settling transactions would work in practice. What would happen if the settlement process was delayed because of insufficient stock or credit? Or if it could not be completed because a registrar refused to register a stock transfer, or procedures had to be used to correct errors?"[162]

According to the SIB, applications were received in "early 1996" and from January to July, a dedicated team was formed at the SIB to oversee the final approval process (Smith 1996). Discussions and negotiations continued throughout this period "with a number of key institutions as well as CRESTCo" on the legal, technical, contractual, and commercial elements of the proposed systems and applications (Smith 1996, p.55).

---

[161] In (Euroclear 2005a, p.5)
[162] In (Smith 1996, p.55)

It was also realised at a late stage that the Financial Services Act also had to be changed to enable the "authorisation of any person inputting instructions to CREST on behalf of another". Amending legislation was rushed through Parliament in late May, leaving only seven weeks for firms to apply for authorisation and their applications to be considered (Smith 1996, p.56).

As can be seen from the above, the SIB was not some disinterested gatekeeper, but was interacting with CRESTCo from the "early work on developing the system", to "avoid wasted effort later when the applications were received and considered" (Smith 1996, p.56). It is also acknowledged that CRESTCo also contributed to a relationship of trust with open and truthful publication of bulletins describing difficulties encountered and problems (Smith 1996, Interview D 2006).

The architecture of CREST

The CREST system was developed as a Central Securities Depository (CSD) for Guernsey, Ireland, the Isle of Man, Jersey and the United Kingdom. It provides electronic holding and settlement facilities for corporate securities (both equities and bonds) constituted under the laws of those jurisdictions and for UK government securities ("Gilts")[163].

Use of CREST is voluntary from the perspective of the issuer and, in general, is also voluntary for the transacting parties[164].

Securities admitted to CREST are called "Participating Securities". All shares in companies registered under the UK Companies Acts are *eligible* for participation in CREST.

The system provides precise mechanisms for transfers of securities between investors, either where both are CREST Members (holding their securities in

[163] UK legislation defines securities as "shares, stock, debentures, debenture stock, loan stock, bonds, units of a collective investment scheme within the meaning of section 235 of the 2000 Act4, rights under a depositary receipt within the meaning of paragraph 4 of Schedule 2 to the Criminal Justice Act 1993, and other securities of any description, and interests in a security".
[164] An exception to this principle was introduced in the UK Uncertificated Securities (Amendment) Regulations 2000 which enabled an issuer to provide in the terms of issue of a UK security for that security to be issued in entirely uncertificated form.

uncertificated form) or where one is a CREST member and the other holds securities in certificated (paper) form.

Securities held in CREST are "uncertificated"; that is, they are recorded in CREST in electronic form and no physical certificates exist for such securities. Securities held in CREST may only be transferred by means of secure electronic instructions. Members effect settlement of a transfer by sending an electronic instruction to CREST to make (or receive) a delivery of securities.

Generally, legal title to shares (or their equivalent) is conferred by an entry on a relevant register of securities. This is true for CREST-eligible shares, whether they are held in uncertificated form in CREST or certificated form outside CREST. In the UK the register of uncertificated securities is constituted by an appropriate CREST record, which is considered as evidence of legal title.

In relation to domestic securities, CRESTCo is not a custodian or depository in the traditional sense. It does not hold any of the underlying securities itself or intermediate the ownership chain. It simply provides a means for the owners of those securities to hold and transfer them securely in electronic form (CRESTCo 2005)[165].

Roles, competences, and relations

The CREST settlement platform defines in a very precise and material way a number of interrelations among the human and material entities that come together to form the settlement system and also link with other external heterogeneous entities in the wider financial system to frame the UK securities market. It establishes a stable and reliable context in which "objects and obligations are clearly mapped out and can be intersubjectively recognised", allowing for "reliable and predictable encounters" and calculation (Slater 2002).

[165] CRESTCo is not a custodian or depository and does not hold any of the underlying securities itself or intermediate the ownership chain. It only provides a means for the owners of those securities to hold and transfer them securely in electronic form.

By tracing the links between all these entities it is possible to see how the settlement system itself is assembled.

A visualisation of the interrelations between the various entities that make up the UK's settlement systems can be seen below. The various components are explained in more detail in the text that follows.

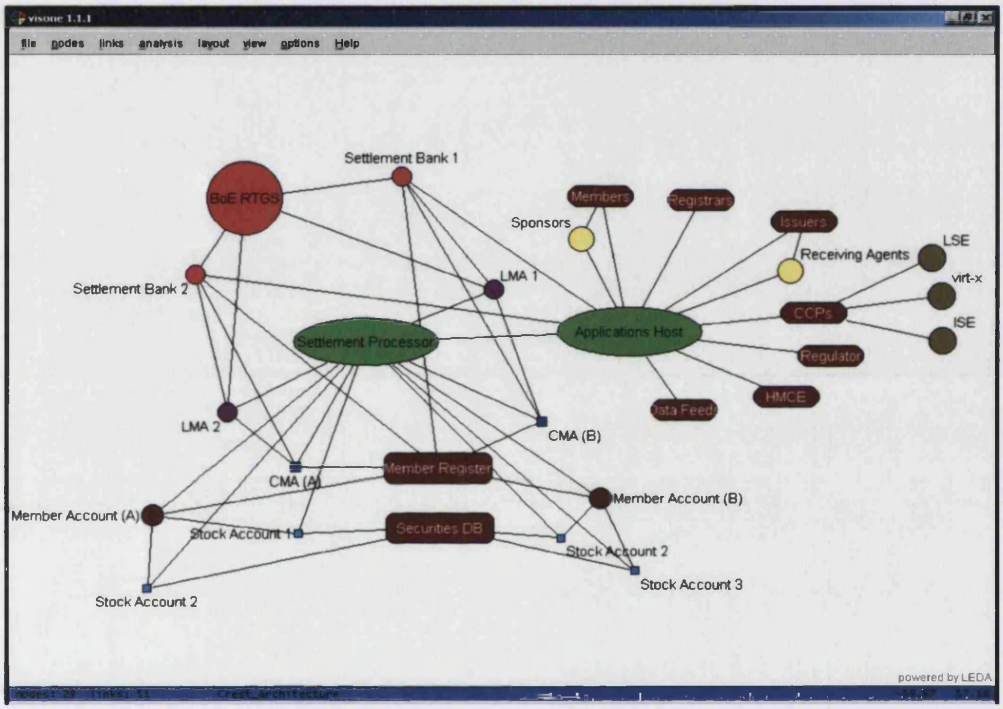

Figure 14: Key components of CREST and their interrelations

Users

Any entity that has the computer and network connection to CREST and can therefore send messages to and receives messages from the CREST system. Such an entity (corporation or individual) will either send and receive messages on its own behalf, on behalf of others, or may act in both capacities.

Linked to Users are Operators who are authorised by a User to access the CREST system via that User's gateway computer. The Operator may be a person or a computer process. Operators are linked to Users, and can access only data relevant to that specific User. Each User must have at least one Operator, who is allocated an Operator ID by CRESTCo when the User is set

up on the system. Users may also choose to create additional Operators and CREST does not restrict the number of Operators which a user may have.

Sponsors
An entity that has computer and network connection to CREST but sends and receives messages on behalf of others who have entered into contractual relations with CRESTCo.

Members
A member is a person or entity whose name appears on the Register of securities. As well as being able to hold and transfer securities through CREST a member is also able to make and receive payments through CREST's payment arrangements.

Some CREST members act as nominees or custodians on behalf of investors, in which case it is the nominee's or custodian's name rather than that of the investor which appears on the register. Such an investor does not have legal title to the securities (i.e. is not the legal owner), but is a "beneficial owner".

Investors transacting in securities through CREST fall into one of two categories:

> Full Member: A transacting party that also maintains the equipment necessary to communicate with CREST.
> Sponsored Member: A Member that sends and receives messages through a Sponsor. Individuals who hold securities through CREST generally do so as sponsored members [166].

CRESTCo has the power to suspend (or disable at the system level) a membership in a range of circumstances, including where the member has become, or appears at risk of becoming, insolvent. The effect of disabling a member is that no further settlement may take place involving the suspended member. The purpose of this power is to protect other members from the risk

[166] Sponsored members include individuals, whom CRESTCo terms "Personal Members" to distinguish them from sponsored members which are corporate bodies.

of legal challenges that might arise in relation to any transactions settled and registered through CREST after the commencement of insolvency proceedings. Suspension is likely to be lifted once the insolvent member is under the control of an insolvency practitioner[167].

Following suspension in insolvency-related circumstances CRESTCo will normally proceed to terminate the member's participation in CREST and recertificate (in paper form) the member's holdings of securities in CREST. Once recertification has taken place, the issuer's Registrar will then deliver the certificates to the terminated member's registered address.
Settlement Discipline

There are a number of other entities that participate in CREST but do not hold and transfer securities.

Registrars
They maintain records *reflecting* the legal register of UK securities maintained by CREST. They also have certain other registration and record keeping responsibilities set out in law. In the CREST system the role of Registrar describes an entity charged with retrieving and responding to registration notifications and instructions generated by the CREST system. They are also permitted to credit and debit units of a security into and from members' accounts (e.g. when securities are issued or redeemed).

The Registrar may be the issuer of the security for which it is admitted as Registrar to the system, or may be a Service Registrar acting for a number of Issuers, in which case it acts as a Sponsor for the issuer. A Registrar cannot be a party to a transfer or any message relating to payment.

CRESTCo and the Registrars for UK securities perform a reconciliation with each others register as follows:

[167] It is also possible that a member may be suspended and subsequently re-enabled in some non-insolvency-related circumstances. For example, a member may be suspended for some operational reason or for breach of CREST Rules.

- A daily reconciliation of the total balance of each Operator register of securities with the corresponding issuer's record of securities, allowing for all stock deposits and withdrawals;
- A daily reconciliation of the balance of each stock account in CREST which has moved that day, with each balance on the corresponding issuer's record of securities which has moved that day;
- A periodic reconciliation of all stock balances in a security with all balances on the corresponding issuer's record of securities.

Where a security cannot be successfully reconciled, CRESTCo's normal practice is to disable the relevant security for settlement purposes.

Receiving Agents

CREST uses the term to describe an entity that sends and receives messages on behalf of an Issuer in the context of a Corporate Action. In terms of access to CREST functionality, a Receiving Agent is considered as a Member and consequently, unlike a Registrar, is also able to make and receive payments through the CREST payment mechanism and has access to the system functionality available to Members. A Receiving Agent can be considered as a Sponsor for any Issuer for whom he acts.

Settlement Banks

They provide payment services to CREST Members relating primarily to the payment and receipt of considerations generated by transfers but also other types of payments. A Member appoints at least one Settlement Bank, which is responsible for the cash movements associated with settlement for that member. Settlement Banks control the amount of credit they extend to customers in CREST by the use of a system of "debit caps". As part of the settlement process, CREST measures the effect of transactions to ensure that they would not result in a debit cap being breached.

Issuers

Issuers are entities that define and put into circulation a particular security. Although Issuers need to be able to send and receive messages to and from

CREST, they generally do so through a Registrar or Receiving Agent operating as a Sponsor to participating Issuers.

Other Participants
The following groups complete the list of system participants:

- Central Counter Party (CCP) participants;
- Central Banks;
- Other CSDs;
- Voting Service Providers;
- Information Providers;
- Issuing and Paying Agents (IPAs);
- Regulators (e.g. FSA, London Stock Exchange, Inland Revenue, Auditors);
- The CREST System Controller
- The network providers;
- Product providers;
- Statistical agencies.

All participants have access to base data (e.g. security details, names and addresses of participants etc), but access to most CREST functions is determined according to participant type.

Accounts

Member Account
Each Member has an Account that records the number of securities held by that Member. It is the name of the account, rather than the Member, that is entered on the relevant register of securities[168].

Stock Account
Each Member Account is divided into Stock Accounts with each such account recording that Member's holding *of a particular security*[169]. Stock Accounts should correspond to entries on the relevant issuer's register for that stock.

---

[168] If a member has more than one account all but one will have an additional alphanumeric identifier to enable the member to have designated holdings on the register.

Cash Memorandum Account

Each Member has one or several Cash Memorandum Accounts (CMAs) that are electronic payments accounts maintained in CREST[170]. A CMA records the net cumulative CREST payments that the member makes and receives in the course of a settlement day.

Before the start of each settlement day, the system sets each member's CMA to zero. During the course of the day, at the point of settlement of any transaction under which payment is to be made by a CREST payment, the system debits the paying member's CMA and credits the payee member's CMA in respect of the appropriate amount. Subject to any agreement between the Member and his Settlement Bank, the balance on the CMA at any time during the settlement day represents the net amount which each Member owes to (or is owed by) his Settlement Bank in respect of CREST payments in the relevant designated currency made during the settlement day.

Legal Record and Operator Register

This records title to, or interests in, securities held in dematerialised form within CREST. It is itself made up of a number of parts including:

- The Receiving Database, which receives stock and cash postings (per transaction) from the CREST Settlement Processor;
- The Ledger Database, which converts the stock and cash postings received from the Receiving Database into a form in which they can be more conveniently communicated to users and maintains the total holding balances per CREST member per security.

Securities in CREST

When a security becomes a participating security, units of that security become *eligible* to be held and transferred through CREST. But holders of a participating security have a *choice*: they can either hold their units of the security *in* CREST or *outside* CREST in certificated (i.e. paper) form, unless

[169] A member has one stock account in respect of each separate security held.
[170] A member may have CMAs in respect of central bank money payments in euros and sterling and in respect of assured payments in US dollars

the terms of issue permit the security to be held and transferred *only* in uncertificated form. Except in the latter case, each participating security is therefore capable, at any moment, of having units in issue in both certificated and uncertificated form. The effect of the legal framework is that securities that are held in uncertificated form are transferred when entries are made on the CREST Register.

To the extent that a participating security is held *in* CREST it is a "Registered Security". Securities that exist outside CREST in "bearer" form can be admitted to CREST provided that a Register is created on which the transfers of the units held in CREST are recorded.

Issuers applying for the admission of securities to CREST must complete and return the relevant Security Application Form for each separate security to be admitted. The Security Application Form provides the basic information concerning the security necessary for CRESTCo to enter the details in to the CREST system. It also forms the basis of the Issuer's contract with CRESTCo in which the Issuer gives certain undertakings and acknowledgements to CRESTCo.

It is the Issuer's responsibility to ensure that the CREST Regulations have been complied with and a security is validly admitted to the CREST system and CRESTCo relies on the Issuer in this respect.

The admission of the security takes place at the point at which CRESTCo enables the security for settlement in the system. If a security is admitted which is not in fact eligible to be a participating security, then the Issuer will be in breach of statutory duty and have a liability to compensate persons who suffer loss as a result of such breach.

The two most important conditions for the admission of a security are that the security must be fungible and freely transferable [171]. There is no requirement either in any of the CREST Regulations or the CREST Rules that a security be listed on an exchange before it is admitted to CREST.

Transaction types

In terms of transaction types, each one represents either a different combination of movements of securities and cash or a different set of system consequences that flow from those movements.

Transaction types include:

- The dematerialisation of securities into CREST;
- The rematerialisation of securities out of CREST;
- Deliveries of securities from one CREST member to another with or without a corresponding payment;
- Stock borrowing and lending, repo, and collateral movements;
- Certain corporate actions;
- International deliveries to or from a counterparty in another CSD.

In addition, certain types of transaction are generated centrally by the system itself. In general, these arise as follows:

- In circumstances where an earlier transaction has been input to the system and a centrally generated transaction is derived from the first input (e.g. a stock loan return derived from the settlement of a stock loan transaction);

[171] Securities in CREST are identified by their International Security Identification Number (ISIN) and units of a security credited to the account of a CREST member are, in system terms, indistinguishable from any other unit of a security with the same ISIN. Units of a participating security must therefore be fungible (i.e. identical in all respects, including in respect of entitlement to benefits) or, to the extent that they are not, admitted to CREST as a separate participating security with a separate ISIN. Issuers must make a separate application in respect of each separate security or class of security. A security is regarded as being a separate security or class of security if it differs in any respect from a security that is already admitted to CREST.

- Where necessary, to reflect the impact of a corporate action on an unsettled transaction (e.g. claims and automatic transformations);
- In the context of RTGS payments, where the system automatically creates repo transactions as part of the self-collateralisation function.

Communications

Securities held in the system are transferred as a result of electronic messages being sent to or from the CREST system. CREST receives messages sent by or on behalf of holders of a participating security, processes these messages and sends electronic messages to the relevant Registrar. All entities that hold securities through CREST and all Issuers who have securities admitted to CREST need to have a means of communicating with CREST. They can either have a direct connection to the CREST system as Users so as to send and receive their own messages or have messages sent and received on their behalf by an entity with a connection to the CREST system such as a Sponsor[172].

A User can access CREST in the following ways:

- Using a file transfer interface (including an ISO15022 compliant interface);
- Via an interactive screen-based interface;
- Using a combination of these methods.

Users are supplied with a free copy of the CREST interactive software, the Graphical User Interface (GUI).

The User has to contract with one or more of the approved CREST secure network providers for connection to CREST.

[172] Both the CREST Regulations and CRESTCo's documentation therefore use terminology which describe participants in the system both in terms of their business role (e.g. "member") and of their functions of sending and receiving messages on behalf of that member or others ("user"). From the legal perspective, the explanations of the communications structure used in CREST and the different types of participant must therefore be understood together.

It is the network provider that then supplies the User with one (or more) gateway computers to be located in the User's premises. SWIFT, the international interbank communications provider and messaging standards body, and BT Syntegra provided the secure communications networks for the exchange of electronic messaging among the system participants[173].

On the gateway computer are located some elements of the secure communications infrastructure provided by the network providers and CRESTCo (in particular a tamper-resistant hardware unit within which are stored the unique software 'keys' used to authenticate (separately) inbound and outbound messages). These keys are kept secret within the unit and are never made accessible to the user.

A gateway computer can only have one User in normal circumstances but a User can have one or many gateways. Each gateway computer is uniquely identifiable to the network provider and has its own unique set of security keys, and this unique identity is contained in all messages sent to CREST.

Users may, if they choose, allow the Members on whose behalf they act to be Operators for them as Users, giving them limited access to CREST functionality (e.g. to specific functions, specific member accounts or read-only access). The Member in this case, however, can only access the CREST network through a gateway of the User. The User therefore remains responsible for the security of communication across whatever network is used to transport data between the member and the user's Gateway. It is for the User to determine to which member accounts and functions the Member may have access.

The User may choose to allocate an Operator terminal to the Member on whose behalf it acts for dedicated use by that Member. The Operator terminal may be located in the User's premises (access being by a LAN, and therefore the

[173] The accreditation process carried out by CRESTCo involves a series of technical tests to check each network provider's compliance with technical specifications relating to the relevant components proposed to be provided by that particular network provider in terms of security, resilience and performance.

responsibility of the User) or in the Member's premises or more remotely (access being by a WAN, and therefore also the responsibility of the User).

As all participants rely on the messages sent and received through the system, UK law provides a key legal instrument to enable participants and CRESTCo to take action in reliance on proper CREST messages through the concept of a "Properly Authenticated Dematerialised Instruction" (PADI) (CRESTCo 2002a, p.27). Any message that passes the authentication test is considered as a PADI. This can be:

- A message sent through the system which complies with the Operator's specifications for messages (including those relating to security) and which relates to an uncertificated unit of a security or to a right, privilege or benefit attaching to or arising from such a unit or relates to the details of a holder of such a unit;
- A message to or from a stock exchange, clearing house or CSD

The network providers are responsible both to their clients and to CRESTCo for ensuring that only PADIs are transmitted to the CREST Applications Host. CRESTCo treats, without further reverification, all messages transmitted by the network providers to its Applications Host as being properly authenticated dematerialised instructions and thus as comprising the requisite authority for CRESTCo to act in accordance with them. CRESTCo itself is permitted to use communication and messaging arrangements that diverge from these provisions so as to communicate with other market infrastructure providers such as stock exchanges, clearing houses and central securities depositories using their proprietary messaging arrangements

The process of settlement in CREST begins in one of two ways, depending on whether the trade is communicated directly to CREST by the Members involved in the transaction or is communicated to CREST through what is referred to as a "trade feed" from, for example, a stock exchange on whose trading platform the trade was agreed and usually after the trades have been

cleared by a central counterparty, or from a provider of matching services such as Omgeo or Axion4 [174].

The Applications Host

Those parts of the system that communicate with participants, undertake pre and post settlement processing and otherwise receive, manage and control the processing of messages are known collectively as the Application Host.

Matching

Once CREST has received a settlement instruction, the system will endeavour to match it with another instruction. With the exception of certain transactions (e.g. those used in the context of a delivery to or by a receiving agent in a corporate action), all transactions input by CREST members are required to be matched before they can proceed to settlement.

The matching process involves the CREST system searching to find another instruction the key features of which (e.g., identity of counterparty, identity of the security, number of units of the security, consideration, intended settlement date etc) mirror those of the first instruction.

Once the matching instruction has been inputted and/or found, the two sides of the transaction are locked together and may only be deleted with the consent of both parties. After matching has taken place, the system takes no further action until the date specified by the parties as being the date on which they intend the transaction to settle.

Both the processes of matching described and the process of settlement are carried on throughout the working day ("real time" processing). The system will check a transaction which is awaiting matching or settlement upwards of 300 times in a normal operating day. If a transaction entered in to the system by the parties during the day matches and becomes eligible for settlement, it will immediately proceed to settlement.

[174] Where CREST receives a trade feed the CREST system automatically creates the transaction inputs according to pre-defined rules and the election of the settlement parties concerned. The settling members must then input their own corresponding instructions.

The Settlement Processor

The CREST Settlement Processor receives messages from the Applications Host for settlement, positions the resource, and concludes the settlement process by means of a settlement algorithm and various associated optimisation routines designed to improve the settlement rate of the system and reduce transaction failures. CREST uses for this purpose what is called the "Circles" optimisation process that is designed to resolve situations of settlement gridlock which can arise where delivery of one type of scarce resource (either securities or payment 'headroom') is dependent upon receipt of another scarce resource (also either securities or 'headroom')[175].

Pre-settlement checks

At the start of settlement on the intended settlement date, the CREST system checks that:

- The stock account of the transferor is credited with sufficient securities;
- The transferee has sufficient "headroom" beneath his "debit cap" (i.e. is able to make the required payment);
- The transferee's settlement bank has sufficient credit on its Bank of England account (reflected in its Liquidity Management Account in CREST) for the transaction to settle.

Where these and other tests are satisfied, settlement of the transaction may proceed.

Where the tests are not satisfied, the system will repeat the test in each settlement cycle during the settlement day until the required resource becomes available.

The transaction will only be settled once the resources are available to settle it.

Transactions not settled on the intended settlement day are carried over to the next day, and so on, until they are settled (or match deleted by the parties).

[175] Details of the CREST "Circles" optimisation algorithm can be found in the Appendix

Settlement

At the moment of settlement, the CREST system simultaneously:

- Debits the stock account of the transferor;
- Credits the stock account of the transferee;
- Credits the Cash Memorandum Account (CMA) of the transferee;
- Debits the CMA of the transferor;
- If the consideration of settlement is euros or sterling;
    - Debits the Liquidity Management Account of the transferor's settlement bank;
    - Creates a payment instruction to the Bank of England;
- Creates a notification or instruction for the registrar in relation to the transfer of title.

In the case of UK jurisdiction, the debits and credits made to the stock accounts of the transferor and transferee have the effect of registering a legal transfer of title.

The CREST payments mechanism

The payment arrangements of the CREST settlement system are important to focus on in some detail because they represent an important point of interface with another market structure, the national inter-bank payment system, that is vital to the detachment and attachment processes that make the trouble-free conclusion of a securities market transaction possible. As such it is a big dependency for the settlement system and one that is defining of the exchange architecture that contributes to the framing of the UK securities market. The interface is also of importance to the Central Bank because of the credit extended by the Settlement Banks that participate in the settlement system to entities engaged in securities transactions. As such, this interface can represent a potential crossover point of risks from the financial markets into the banking and monetary systems, with wider systemic implications.

Unlike other settlement systems that are much more tightly integrated with the payment systems in their jurisdictions, in the UK CRESTCo is not a bank and

is not authorised to accept deposits or extend credit. CREST Members (as opposed to CREST Settlement Banks) are not required to hold accounts with the Bank of England (BoE). They are, instead, required to appoint a Settlement Bank to make and receive CREST payments on their behalf arising from their settlement activity within CREST.

The CREST system provides settlement in central bank funds in euros and sterling by linking with the Bank of England Real-time Gross Settlement (RTGS) wholesale inter-bank payment system that enables the inter-bank payments (i.e. payments among Settlement Banks) arising from CREST transactions to be immediately discharged through the BoE RTGS system [176].

Each Settlement Bank maintains separate account groups in the BoE RTGS payment system to support CREST settlement as well as all other types of payments effected through the BoE RTGS process. Settlement Banks are able to balance their available liquidity between these accounts throughout the day to deploy liquidity as demand arises, either from CREST or from other payment categories.

The foundation of CREST's payment mechanisms is a binding agreement by a selling Member that the generation of a Settlement Bank payment obligation for the buyer's Settlement Bank, which arises upon the debit of the purchase price to the buyer's CMA, is the final payment of the purchase price between the selling Member and the buying Member. As a result, a CREST payment is considered as completed at the moment of debit and credit to the relevant CMAs of the transacting parties.

Under this arrangement, the generation of the Settlement Bank payment obligation is accepted as discharging the buying member's obligation to pay the purchase price to the selling member, because the selling member's Settlement Bank will (under its contract with the selling member) have an obligation to account to its customer for the payment received from the buyer's

[176] The CREST system's payment functionality also includes an assured payments mechanism for US dollar payments referred to as the CREST Assured Payments Mechanism.

Settlement Bank in performance of its Settlement Bank payment obligation owed as principal to the selling member's Settlement Bank.

Settlement Banks are able to control their exposure to their CREST member customers by means of what is known as the Debit Cap function within the CREST system. This is effectively a limit on the net intra-day credit that the Settlement Bank will provide to the Member. The Debit Cap, which is enabled in the system by the Settlement Bank, represents the maximum cumulative net debit position that can be reached at any time during the course of the settlement day on a member's CMA (or CMAs) [177].

Immediately prior to settling each transaction, the CREST system determines the effect of settling that transaction on the cap specified by the Settlement Bank. For this purpose, where the Debit Cap covers a number of CMAs, the system automatically converts the resulting balance into the base currency of the cap by reference to the previous business day's closing exchange rate held within the system. If settlement of that transaction would breach the cap, then settlement does not proceed.

A cap may consist of both an unsecured and a secured limit. Some CREST members are able to give a floating charge over securities that they hold in the system so that their Settlement Bank may give them a higher overall cap (i.e. extend greater intra-day credit to them up to a secured limit set by that Settlement Bank). The legal arrangements for such a facility are matters for the CREST members and their Settlement Banks. In system terms, the member designates a particular account as being "linked" to this cap and which is subject to the electronic "sanction" of the member's Settlement Bank.

At the central bank level, immediately prior to the start of each CREST settlement cycle, the Bank of England irrevocably earmarks the liquidity balance on each Settlement Bank's CREST settlement account held at the BoE

[177] The same cap can cover a number of CMAs in different designated currencies belonging to the same member, provided that the settlement bank acts as settlement bank for the member in respect of the relevant designated currencies and has specified the base currency of the cap. Alternatively, a separate cap may be set for each CMA.

and known as the Minimum Balance Groups (MBGs). This liquidity is protected from all other potential payment system claims during the CREST settlement cycle. The Bank of England then notifies CREST of the liquidity available to each and every CREST Settlement Bank for use in CREST settlement activities. The CREST system queues transactions (i.e. those where the Settlement Bank's customer is paying) against the available liquidity. Only transactions where stock and credit are known to be available are assessed for liquidity in order to minimise wasted liquidity allocation. Where the available liquidity is insufficient to cover all potential settling transactions, uncovered transactions are left to be reassessed in the next settlement cycle.

Liquidity is allocated to transactions according to a central algorithm that does not require intervention by either CREST Members or the Settlement Banks. Once the CREST system has identified a set of transactions for which all resources are available, these transactions proceed to settlement. Securities are transferred within CREST and CREST Members' CMA positions are updated, with payment considered final at the point of debit/credit to CMAs within CREST[178].

The CREST system then notifies the BoE RTGS payment system of the changes to the earmarked liquidity of the Settlement Banks arising from that settlement cycle. Each notification to the BoE RTGS payment system reflects the sum of gross debits between any pair of Settlement Banks and thus reflects the result of a number of underlying transactions. The BoE RTGS system processes the resulting inter-bank transfers, at which point any remaining earmarked liquidity is released. Any automatic or queued (i.e. manual) liquidity transfers between a Settlement Bank's CREST and other payments account groups in the BoE RTGS payment system are then effected. Once

[178] In respect of the RTGS payments mechanism, "finality of payment" refers to both final payment between the CREST Members whose CMAs are debited and credited and between their Settlement Banks in Bank of England funds. Both payments are considered final and unconditional at the moment of debit/credit to the relevant CMAs. In practice, the RTGS payments system operated by the Bank of England is a separate system from the systems operated by CRESTCo and consequently, the actual updates to the RTGS payment system accounts of the Settlement Banks with the Bank of England are never simultaneous with the corresponding entries to CREST members' stock accounts and CMAs.

complete, the liquidity on the MBG is earmarked again and the process begins for the next CREST settlement cycle.

The BoE RTGS liquidity earmarking mechanism

As described above, before the BoE RTGS payment system sends the CREST system details of the amounts of liquidity available to each Settlement Bank on its RTGS MBG for each BoE RTGS currency, the RTGS system earmarks that liquidity.

Earmarking does not involve any actual transfer of funds, but is "a legal effect established by contract" (CRESTCo 2002a). The effect of earmarking ahead of each CREST settlement cycle is to move irrevocably the total sum earmarked in a Settlement Bank's BoE RTGS CREST Settlement Account Group out of the Settlement Bank's control (or, in the case of insolvency, of its liquidator, administrator or creditors), thereby ensuring that the sum earmarked is only available to fund settlement in the CREST settlement cycle which commences after the earmarking.

Once funds are earmarked, the BoE RTGS payment system notifies the CREST system of the value of liquidity available for CREST settlement for each Settlement Bank [179]. The CREST system then records this value on each Settlement Bank's Liquidity Memorandum Account (LMA) and proceeds to the settlement of transactions that do not breach those values [180]. The CREST system prevents the settlement of any transaction in a settlement cycle that would cause the aggregate Settlement Bank payment obligations incurred during that cycle to exceed the balance on that Settlement Bank's LMA for that cycle.

At the end of each CREST settlement cycle, the CREST system sends a message to the BoE confirming the debits to be made to each earmarked fund held by the Bank from the account of each Settlement Bank through RTGS

[179] The amount of earmarked liquidity is reported through an electronic communications link to the CREST system.

[180] Operationally, the CREST system seeks to allocate up to the full value of earmarked funds for settlement of transactions in the settlement cycle.

payment system transfers between the Settlement Banks' CREST Settlement Account Groups on the BoE RTGS system.

Once these payments have taken place, the earmarking is released and the balance of funds, together with any net receipts through self-collateralisation and gross receipts from other Settlement Banks, become freely available to the Settlement Bank (i.e. available for transfer to their Payment Settlement Account Group for use in their own banking operations) [181]. Once transfers between CREST and Payment Settlement Account Groups have been completed, balances on the BoE RTGS system CREST Settlement Account Groups are earmarked for the next cycle of CREST settlement.

Earmarking is a crucial mechanism in the interfacing between the settlement system and the wider securities market, and the banking and monetary systems. This is because it permits finality of payment to be simultaneous with transfer of securities through CREST in the knowledge that sufficient funds are available, dedicated and protected from the insolvency of the paying Settlement Bank[182]. The earmarking process does this by unambiguously defining the points at which the earmarking takes and ceases to take effect and the Settlement Banks' entitlements to any remaining funds in these accounts not used for CREST settlement. This is achieved by a combination of a contractual arrangement between the Bank of England and the Settlement Banks and standing irrevocable instructions from the Settlement Banks to the Bank of England.

---

[181] Transfers between BoE RTGS CREST Settlement Account Groups and between CREST and Payment Settlement Account Groups at the BoE are standard BoE RTGS payment system transfers and subject to the rules and protections of that service. When the buying CREST member and the selling CREST member use the same Settlement Bank, then a payment between the members is final at the point of CREST settlement but, clearly, no inter Settlement Bank payment obligation is generated. Such an "in-house" payment is not applied against a Settlement Bank's earmarked liquidity, because the relevant Settlement Bank payment obligation (being owed direct to the selling CREST member, rather than his Settlement Bank) is not settled across accounts at the Bank of England as part of the procedures described above. It is settled by postings to the customer's (CREST member's) account with the Settlement Bank concerned.

[182] The earmarking has the legal effect of limiting the Settlement Bank's entitlement to the earmarked funds to a right as against the Bank of England to a return of such funds (if any) as may be left over after the earmarked funds have been applied to complete the payments made during the relevant CREST settlement cycle.

Once the funds have been earmarked, the Settlement Bank's claim in respect of the funds is substantively a claim to the balance which is left at the end of the relevant CREST settlement cycle after the aggregate payments made during that cycle are deducted from the opening earmarked balance. The claim is incapable of being determined until the end of the relevant CREST settlement cycle and its payment is contingent upon completion of the cycle.

The earmarking mechanism also allows for the creation of additional liquidity *during* the cycle through the self-collateralising repo process and the repayment of liquidity as existing self-collateralising repos are closed. If a Settlement Bank's insolvency intervenes between the earmarking of its funds and receipt by the Bank of England of an instruction from the CREST system to complete the associated debits and credits, the effect of this earmarking is to prevent the Settlement Bank's liquidator or other insolvency office-holder from stopping completion of the settlement in CREST or the application of the earmarked funds in payment to the other non-defaulting Settlement Banks.

The Liquidity Management System

The procedures outlined so far in this section are part of the broader set of Liquidity Management Services that CRESTCo provides to the Settlement Banks in order to manage their liquidity in connection with the CREST DvP mechanism.

As part of providing these Liquidity Management Services, CRESTCo uses the services of a network provider to send and receive electronic messages to and from the BoE's systems.

The network and associated equipment and services used by CRESTCo to receive electronic messages from the Bank's systems and to send electronic messages to the Bank's systems is referred to as the "CRESTCo-Bank link network" .

The interface between the "CRESTCo-Bank link network" and the BoE systems – which represents the point at which electronic messages sent by

CRESTCo to the Bank's systems leave the "CRESTCo-Bank link network" or, as the case may be, electronic messages sent by the Bank to the "CRESTCo-Bank link network" reach that network – comprises a piece of equipment known as a switch operated by CRESTCo as part of the "CRESTCo-Bank link network".

The Liquidity Management Services are all linked to the CREST Liquidity Management System (often referred to in the CREST documentation and within settlement circles as the LM System). The main components of this system are:

- Software for the maintenance and amendment of Liquidity Memorandum Accounts (LMA) to record Settlement Bank liquidity and its allocation to individual transactions [183];
- Systems and services for the receipt of notification of liquidity from the Bank of England and notification of payments to the Bank of England;
- Contingency procedures.

The CREST LM System and the BoE's systems communicate with each other during each settlement day for RTGS payments by using a sequentially numbered 'heartbeat' message. At the start of each such settlement day the first heartbeat message will establish that both systems are available and ready to begin operation. Following these initial heartbeat messages, the Bank will send the first Liquidity Earmark Notifications to the "CRESTCo-Bank link network".

Before the commencement of any CREST settlement cycle, the Bank of England is required to send to CRESTCo a separate Liquidity Earmark Notification in respect of each of its RTGS payment system currencies. The Liquidity Earmark Notification will contain the details of the amount (the 'liquidity earmarked amount') that has been irrevocably appropriated in each

[183] A separate LMA for each BoE RTGS payment system currency is operated for each RTGS payment system Settlement Bank that provides CREST payment facilities in that RTGS payment system currency.

RTGS payment system Settlement Bank's Sterling and/or Euro CREST MBG for the purpose of completing payments in respect of the Settlement Bank's payment obligations to:

- Other BoE RTGS payment system Settlement Banks made in the relevant RTGS payment system currency;
- The Bank of England to be settled under the self collateralisation arrangements through the RTGS payment system.

Prior to the beginning of each CREST settlement cycle, the balance on each RTGS payment system Settlement Bank's LMA is re-set to zero. Upon receipt of the Liquidity Earmark Notification in respect of each RTGS payment system currency, the CREST LM system records the details of the liquidity amount earmarked on each RTGS Settlement Bank's LMA. The amount of liquidity recorded on an RTGS Settlement Bank's LMA is fixed for the duration of the relevant CREST settlement cycle. The Settlement Bank will not be able to amend the balance once recorded in respect of the relevant CREST settlement cycle.

During the CREST settlement cycle, all transactions of a CREST Member that uses the BoE RTGS payment system liquidity are queued against the LMA of the CREST Member's RTGS payment system Settlement Bank. The liquidity queue may contain transactions from all the Members for whom the Settlement Bank acts in that currency. Liquidity is allocated to the transactions of the CREST members according to a central algorithm. Only those transactions which, in accordance with the order of priority of the liquidity queue, would not cause the balance on the relevant RTGS payment system Settlement Bank's LMA to go into debit, may proceed to settlement in CREST - resulting in the posting of the corresponding debits and credits to the relevant stock accounts and CMAs in CREST.

Having completed a CREST settlement cycle, the CREST LM system will generate a CREST Settlement Notification that is sent to the BoE's systems by means of the "CRESTCo-Bank link network".

The CREST Settlement Notification confirms, for each BoE RTGS payment system Settlement Bank, its liquidity earmarked amount in each RTGS currency notified to the CREST LM system under the related Liquidity Earmark Notification. In addition, in relation to each RTGS Settlement Bank in respect of the completed CREST settlement cycle, it provides details of:

- The aggregate amount of the payments made in each RTGS currency during that CREST settlement cycle by that RTGS Settlement Bank to another RTGS Settlement Bank, by way of debit to the CMA of a CREST Member for whom the first RTGS Settlement Bank is acting and corresponding credit entry to the CMA of a CREST Member for whom the second RTGS Settlement Bank is acting;
- The aggregate amount of the payments made in each RTGS currency during that CREST settlement cycle to that RTGS Settlement Bank, by another RTGS Settlement Bank, by way of debit to the CMA of a CREST member for whom the second RTGS Settlement Bank is acting and corresponding credit entry to the CMA of a CREST member for whom the first RTGS settlement bank is acting;
- The aggregate amount of the payments made in sterling by that RTGS Settlement Bank to the Bank of England by way of repurchase price made by way of system-transfer during that CREST settlement cycle under the self-collateralisation arrangements;
- The aggregate amount of the payments made in sterling by the Bank of England to that RTGS Settlement Bank by way of purchase price made by way of system-transfer during that CREST settlement cycle under the self-collateralisation arrangements;
- The amount of the liquidity earmarked amount that was not used during that CREST settlement cycle.

At the end of each CREST settlement cycle period, the balances on each LMA are re-set to zero ahead of the start of the next CREST settlement cycle.

At the time indicated in the daily timetable, the CREST LM system flags the last CREST Settlement Notification sent to the BoE's systems indicating that the CREST LM system is ready to close. Once the flagged CREST Settlement Notification is received by the BoE's systems, the BoE's systems may respond in one of two ways depending on the position of the 'end of day unwind' process that forms part of the self-collateralisation arrangements. If the BoE's systems are not ready to close, then Liquidity Earmark Notifications may continue to be sent to, and received by, the CREST LM system; and, if so, the 'end of day unwind' process continues to operate and CREST Settlement Notifications are sent to, and received by, the BoE's systems (and each such Notification indicates that the CREST LM system is ready to close). Once the BoE's systems are ready to close, they generate a closedown message and send that message to the CREST LM system. On receiving the closedown message, CREST settlement under the 'end of day unwind' process ceases.

The use of securities as collateral

As already discussed, each CREST Member will have a certain Debit Cap for payments generated in CREST, agreed in advance with a Settlement Bank and which may consist of both an unsecured and a secured limit. Some Members are able to give a floating charge over securities that they hold in the system so that their Settlement Bank may give them a higher overall cap (i.e. extend greater intra-day credit to them up to a secured limit set by that Settlement Bank). To do this, a Member must designate a particular account as being "linked" to the Debit Cap and which then becomes subject to the electronic "sanction" of the Settlement Bank.

The CREST system values the securities recorded in the "available balance" of the linked account by reference to the previous business day's closing bid price and creates additional credit "headroom" based on a combination of the valuation of the securities and a margin specified by the Settlement Bank. In order to prevent purchases of further securities credited to a linked account

generating continual additional headroom, the additional headroom is subject to a "Secured Cap" set by the Settlement Bank.

The setting-up of the link in the system does not of itself establish the Settlement Bank's charge and the scope of the charge in the security document may differ from the quantity and nature of the securities in the linked account.

CRESTCo does not verify or otherwise monitor whether the link is consistent with the security arrangements in place between a Member and its Settlement Bank. However, the Settlement Bank may enquire of CREST at any time during the on-line day as to which member account(s) are linked to a cap which the Settlement Bank has set and the amounts of each line of securities which at that time is contributing to the secured limit.

Self-collateralisation

Settlement in central bank money in CREST is also assisted by what are referred to as self-collateralisation facilities whereby securities *in the course of settlement* may be used to generate additional liquidity for the buyer's Settlement Bank. This process, referred to as self-collateralisation, operates through back-to-back repos from the purchasing Member to its Settlement Bank, and then, from the Settlement Bank to the Bank of England [184].

Transactions are eligible for self-collateralisation for sterling payments only and where the stock is eligible for repo to the Bank of England (as determined by the Bank) and the purchasing Member has entered into a repo agreement with the Settlement Bank.

Operationally, the creation of self-collateralising repo (SCR) transactions in CREST is fully automated, with SCR transactions being created by CREST where the transaction meets the predefined criteria. The facility is generally used by CREST Members that hold securities as principal. Such Members

[184] Repos, or repurchase agreements, are financial instruments in which the seller sells securities in return for cash and agrees to repurchase those securities from the buyer for an agreed, but greater, sum of cash at some time in the future. The agreed sum represents all of the cash borrowed plus some interest, which is referred to as the repo rate.

enter into a contractual arrangement with their Settlement Banks, which in turn has equivalent repo arrangements with the Bank of England. The value of the additional liquidity created depends upon the range of assets eligible for repo with the Bank of England (generally UK gilts). Where such arrangements are in place, the CREST system identifies those transactions that are eligible for repo and automatically creates self-collateralising repo (SCR) transactions from the Member to his Settlement Bank and from the Settlement Bank to the Bank of England. The SCR transaction from the Member to the Settlement Bank is against payment; the SCR transaction from the Settlement Bank to the Bank of England is free of payment in CREST but generates the extension of additional liquidity in the BoE RTGS system. These transactions settle simultaneously with the underlying transaction and the extension of additional liquidity in the BoE RTGS system to the Settlement Bank acting for the buyer.

Where securities required to meet a delivery are currently "out on repo" to the Bank of England, CREST automatically seeks to unwind the repo to permit delivery. This requires the Settlement Bank to have sufficient liquidity to repay the Bank of England and, equivalently, for the member to have sufficient credit to repay the Settlement Bank. In the general case, these are both available from the cash value of the sale. As before, the repo return transactions settle simultaneously with the delivery.

Closure of repo is also automated and CREST closes repos in order to meet sales, subject to availability of sufficient credit and liquidity to repay the Settlement Bank and the BoE respectively.

The closure of the repo is effected by securities transfers from the BoE's stock account to that of the Settlement Bank "repo members" with a corresponding debit from the Settlement Bank's CREST Settlement Account Group in the BoE RTGS system and further transfer from the Settlement Bank "repo" Member's stock account to the Member's stock account against a CMA transfer of the repurchase price to the CMA of the Settlement Bank repo member.

Other functions of the CREST system

Apart from the central DvP mechanism and the functionalities that support this, the CREST system also processes:

- Corporate actions (e.g. conversions, takeovers, rights issues, transformation/sub-division, voting services)
- Meeting announcements
- Results announcements
- Stamp duty collection

The performance of the CREST system

The speed with which a settlement system can process different volumes of transactions is one of the fundamental parameters according to which the performance of settlement system can be judged.

The capacity of the CREST platform has been configured to accommodate a reasonable estimation of the settlement and other processing volumes likely to be processed by the system each day. However, due to fluctuations in processing volumes during the course of the day, processing times can vary. This is particularly the case at the start of the business day, when all instructions that have been inputted and matched on previous days become eligible for settlement. Processing times are also affected by levels of enquiries by Users and at the level of an individual instruction, the speed with which a file is processed will depend upon the number of messages contained in the file and whether or not the User is using a single or multiple Operators.

The speed with which any message is processed by the CREST platform and a reply is generated is of central importance to the performance of the settlement system. In general, response times are dependent upon

- Available capacity on the CREST Applications Host;
- Environmental factors affecting the CREST Applications Host;
- Software factors;

- Where relevant, the pre-settlement processes (e.g. matching and stock, cash and liquidity checks);
- The availability of certain functions in particular circumstances;
- Factors related to the communications networks.

Another important parameter in the design and implementation of the CREST platform was the need for reliability and resilience. It was seen as essential to protect against failure and provide an uninterrupted service. As a result, many precautions relating to resilience were built into the system, including the provision of standby power, a duplication of communication links, "hot standby" at a remote site, and physical standby arrangements for CRESTCo as a corporate and physical entity.

The "Circles" optimisation routine

In addition to the speed with which transactions are processed and the reliability and resilience of the platform, the performance of a settlement system is also judged in terms of the number of transactions it fails to settle.

In order to minimise transaction failures, settlement platforms include what are referred to as "optimisation routines". The CREST "optimisation routine" was known as "Circles".

In this routine, a "circle" could exist in four basic forms:

- A pure 'stock circle': where one Member cannot deliver a particular security to another Member until it has received those securities as a result of the settlement of another transaction;
- A pure 'cash circle': where one Member's headroom is insufficient to 'pay' another Member for delivery of one line of security and is dependent on its CMA being credited as a result of the settlement of a transaction in a different line of security;
- A pure 'liquidity circle': where one BoE RTGS payment system Settlement Bank's liquidity is insufficient for it to 'pay' another

Settlement Bank and is dependent upon its LMA being credited as a result of a transfer from another Settlement Bank;

- A combination of two or all of the above.

In normal circumstances, Circles is run at times of the business day set out in the daily timetable, but may be run more or less often at the discretion of the System Controller.

Generally the first run of Circles will include all unsettled transactions in all settling security categories. Later runs of Circles during the day will include only transactions in gilt securities and cash only transactions.

When Circles is run, the CREST system identifies all those instructions which are due to settle on that day but have not yet done so and which do not have a zero priority. It then calculates the potential stock account balances, cash and liquidity positions that would result if all those items were settled. Some stock account, cash balances and LMAs would be likely to be negative (i.e. in the case of cash, in excess of the available headroom) if all such transactions were to be allowed to settle and the system therefore looks at each potential cash, stock and liquidity position where there is a negative balance and one by one removes the effect of each relevant transaction in reverse priority order. As each transaction is removed, the system recalculates the notional stock, cash and liquidity positions affected by the removal and carries on doing so until it would be possible to settle all such transactions in such a way as would result in all balances and positions being zero or positive (i.e. within the available headroom in the case of cash).

Having identified the relevant transactions, the system then "dis-applies" the normal requirements for stock account, cash balances and LMA to be positive and allows settlement to occur on the basis that the net result is zero or positive. In system processing terms, the system processes the relevant transactions one at a time and consequently, during the process of settling the relevant transactions, it is likely that some stock accounts would momentarily record a negative balance, that some caps would momentarily be breached and

the sum of liquidity debits (less credits from the self-collateralisation process) might exceed the initial balance on a Settlement Bank's LMA. As all such negative balances and liquidity positions would be restored to zero or positive values by the end of the Circles process and similarly all caps would be complied with, the transactions are allowed to proceed nonetheless.

Hardware

What makes a system such as CREST stand out in terms of ICTs is the very high requirements it has in terms of satisfying very high and unexpected peaks in processor demand, high volumes of transactions, high numbers of user accounts, high speeds of processing of transactions, reliability, robustness, and resilience, easy scalability without having to interrupt the operation of the system, high demand for data storage over a considerable lengths of time and so on. The hardware can be as important as the software and the architecture of the system.

At its launch the system utilised two dedicated computer centres in London and Middlesex using Compaq Tandem Himalaya servers (which since the merger between Compaq and HP were re-branded as HP NonStop Servers). It was capable of settling up to 150,000 transactions per day from up to 5 million accounts and with no more than 10 hours downtime per year, an availability of 99.5% (Currie 1997). The computer system was operated and managed by Hoskyns, a company that was to become part of Cap Gemini.

By 2002 CREST was settling 350,000 transactions per day with demand for securities settlement constantly increasing. As a result, there have been moves towards technologies that support easy and extensive scalability such as clustering through the adoption of HP's NonStop ServerNet Cluster technologies. In a benchmark test with HP, the CREST system was able to support the processing of one million transactions, with 750,000 of these in a single three-hour window (Hewlett-Packard Development Company 2002).

Appendix F: A brief backgrounder on Euroclear

Euroclear started as a DvP settlement services set up by the Brussels office of Morgan Guaranty Trust Company of New York (now JP Morgan) for the issuance and trading of dollar denominated Eurobonds. It was based in Brussels and operated under Belgian jurisdiction. The service went live on 1 December 1968 and introduced a number of technological innovations for the time such as pre-settlement matching of instructions, fungibility, and punch-card electronic processing equipment (Shearlock and Ellington). In 1972 a separate corporate entity, Euroclear Clearance System Ltd (ECS), was established to take over the settlement system. In this way ownership of the company was passed to the market participants that used it, with the operation of the system contracted by the company back to Morgan Guaranty in Brussels (Shearlock and Ellington) (Euroclear 1999).

When Euroclear Clearance Systems Ltd (ECS) was established as a separate entity from JP Morgan in the form of a co-operative owned by the users of the settlement system, this was seen as a way of resolving tensions between maximising returns to shareholders and providing a utility service to the market with a duty to plough back into the market any profits made in the form of a fees reduction (Shearlock and Ellington 1994).

During the 1980s Euroclear diversified the instruments and currencies it covered expanding its service offering to include equities, commercial paper, and domestic bonds. All were being traded increasingly on a cross-border basis and settled in many different currencies so it was a logical move for an international CSD to move into these areas (Euroclear 2005b). In addition, because of the often cyclical moves by investors into bonds or equities according to the prevailing economic conditions and the interest rates, diversification was a way of ensuring a steady flow of settlement business, regardless of the prevailing macroeconomic conditions.

On 1 September 1999, ECS signed a letter of intent with J.P. Morgan whereby Euroclear Bank would be established to take over Morgan Guaranty's operating and banking roles with respect to the settlement system (Euroclear 1999).

Appendix G: Existing ways of cross-border securities trading

Despite the absence of dedicated cross-border clearing and settlement systems, trading of securities across borders between counterparties in different jurisdictions does already take place through the intermediation of financial services providers such as global custodians with a presence, through their subsidiaries or through the appointment of local agents, in many separate marketplaces. Because these arrangements are ad hoc and not based on statute, involve a number of intermediaries, often require a wide range of interfacing arrangements, and working capital cannot be efficiently deployed, the costs involved are much higher than they need to be and risks of errors, trade failures, and even defaults are greater (Group of Thirty 1988, Giovannini Group 2001, Group of Thirty 2003, de Carvalho 2004). Issues also arise in relation to the way that the property rights and other legal and fiscal elements pertinent to a particular jurisdiction and intertwined with a security are dealt with.

Apart from cross-border transactions made utilising the services of intermediaries such as custody banks, cross-border settlement can also be achieved via bilateral links between CSDs[185]. These do not, however, allow for full DvP as they are only for "free of payment settlement" transfers (Banking Federation of the European Union 1999, de Carvalho 2004).

Most cross-border transactions up to now have taken place through global custodians and their local sub-custodian and CSD membership arrangements for equities and international CSDs (ICSDs) for bonds. ICSDs also use their

[185] The network of links that exist between CSDs enables a cross-border service to be provided to customers. However, the cost to the customer is considerably higher than the cost of internal services. This is true where one CSD has a direct link to another and still more so where an agent bank is involved as intermediary and has an impact both on transaction charges and custody fees. Thus a typical example of a CSD's internal transaction tariff might be EU1, while for a cross-border delivery this might be between EU15 to EU30. Additionally customers incur further costs in their own back offices when processing cross-border transactions on top of the charge made by the CSD.

local membership of CSDs for such purposes. Progressively the differentiation between these two transaction-processing routes are diminishing with ICSDs pursuing more aggressively cross-border settlement business in asset classes beyond bonds.

Investors may also have their own local agents who manage settlement for them or even their own direct membership at the local CSD, but this entails large fixed costs that may not be justified below a certain level of transaction flows and, in addition, in may jurisdictions there are still rules and laws that restrict membership to national entities.

The costs and risks of cross-border settlement

Securities settlement carries a number of risks, even before considering the further complications introduced by cross-border transactions (Committee on Payment and Settlement Systems 1992, 1995). The most obvious risk is what is referred to as principle risk and describes the situation when one of the two counterparties fails to fulfil the agreed to obligations (e.g. the seller fails to deliver the securities even though payment has been received or the buyer fails to make a payment even though the securities have been transferred by the seller).

Even if a transaction fails before any exchange of assets has actually taken place, the consequences can, nonetheless, be costly, as one of the counterparties may have already based other transactions on the assumption that the assets being exchanged will been delivered. The extra cost of having to acquire those assets at possibly unfavourable terms in a new transaction represents what is referred to as replacement cost risk.

A delay in the completion of the transaction due to errors having to be resolved, operational glitches, lack of processing capacity or speed, cash flow problems etc. can also have serious knock-on effects as one or both of the counterparties may be counting on the timely delivery of the assets being traded to fulfil other obligations, bringing about situations in which defaults in other parts of the financial system might be triggered. This type of risk is

referred to as liquidity risk, although in its Basel II recommendations, the Bank of International Settlements (BIS) opted to define operational risk as a separate risk category (Basel Committee on Banking Supervision 2004).

The overall risk that a particular problem within the overall system might spread and cause system-wide unforeseen damage is described as systemic risk

With the existing mechanisms for settling cross-border securities transactions all these categories of risk are heightened in comparison to an entirely domestic transaction [186].

One such risk relates to unforeseen problems that may arise in relation to a transaction as a result of the different legal and fiscal jurisdictions that govern the different legs of the transaction, with often substantial differences found in how situations of default, bankruptcy, and finality in the transfer of ownership of assets are treated by the local legal and fiscal systems (BNP Paribas Securities Services 2002). There is, for example, an important issue with the possibility of multiple ownership of securities under the existing arrangements (Benjamin 1996, 1998, 2000, Schwarcz and Benjamin 2002). All these issues are often aggregated under the title of legal or jurisdictional risks.

Another category of risk that is specific to the cross-border settlement of securities relates to the central role played in the current arrangements by the custodians and the internalisation within their own corporate structures of many of the elements of the transactions and the accompanying risks. There is a certain concentration of risk within them that could have systemic implications.

Integration of the existing settlement systems is seen as a way of reducing, if not resolving, many of these problems.

[186] There is credit risk resulting from timing differences between the settlement process in a local market and the delivery of the securities to the home CSD, operational risk due to multiple and often complex and unwieldy interfaces between domestic markets, and financing costs inherent in cross-border settlement activities due to the fragmentation of collateral in different domestic settlement systems.

Appendix H: Cross-border settlement initiatives

In the EU especially, due to the greater degree of economic and political integration that has taken place and the introduction of the Euro, there is a strong political drive to establish a single pan-European market in financial services. The secure, efficient, low-cost, seamless and uncontested cross-border settlement of securities is seen as a pre-requisite to such a market. As a result, a number of EU public policy efforts have focused on resolving many of the political, legal, and fiscal discrepancies that might be hampering the integration process among EU member states (Giovannini Group 2001, 2003).

Particular initiatives and proposals have emerged out of the work of the Giovannini Group [187], described by the European Commissions as "a group of financial-market participants, under the chairmanship of Alberto Giovannini, which advises the European Commission on financial market issues"[188]. In relation to cross-border settlement of securities in the EU, the Group states the following:

> "Investor demand for foreign securities has increased sharply within the European Union since the introduction of the euro. However, the EU infrastructure for clearing and settling cross-border transactions remains highly fragmented. Fragmentation complicates significantly the post-trade processing of cross-border securities transactions relative to domestic transactions and creates barriers to the efficient delivery of clearing and settlement services. Barriers can be divided into three main groups:
>
> - National differences in technical requirements and market practice;
> - National differences in tax procedures;
> - Issues relating to legal certainty.
>
> In removing these barriers, there is a consensus within the Group that the EU clearing and settlement landscape could be significantly improved by

[187] The Group was formed in 1996 and has focused its work on identifying inefficiencies in EU financial markets and proposing practical solutions to improve market integration. The Commission's Directorate-General for Economic and Financial Affairs provides the secretariat for the Group. Members of the Directorate-General for the Internal Market and of the European Central Bank (ECB) also participate in the Group's work. The Group has produced four reports. The first report on the impact of the introduction of the euro on capital markets was published in July 1997. Since then, the Group has published reports on the EU repo market, on co-ordinated public debt issuance in the euro area, and a report on EU cross-border clearing and settlement arrangements.

[188] (European Commission 2004)

> market-led initiatives to convergence and/or provide interoperability in technical requirements and market practices across national systems. On the other hand, the removal of barriers related to taxation and legal certainty is clearly the responsibility of the public sector."[189]

The statement of Giovannini Group is useful because it makes explicit how the technical aspects cannot be separated from those of a legal, political and fiscal nature. For the necessary integration to take place, therefore, all these strands have to come together into a new arrangement in a coherent and timely way. Adding to the complexity of the situation is the acknowledgement that while "the removal of barriers related to taxation and legal certainty is clearly the responsibility of the public sector" (i.e. of EU public policy), the technological and corporate/organisational arrangements "could be significantly improved by market-led initiatives".

For a successful new cross-border socio-technical arrangement to come into existence, therefore, a number of different material and institutional elements must be transformed in the same direction and over similar time frame across many different jurisdictions and with the coordination of these efforts being split between political and commercial entities. As de Carvalho points out, "market participants can do little to change domestic withholding tax regulations, or different transaction taxes and stamps collected in the securities settlement, or to hamonize the different ownership and bankruptcy laws applied in each ... country", but that there is "eagerness from the market side to overcome the technical barriers ... such as: national differences in information technology and interfaces" (de Carvalho 2004).

The two major integration initiatives at the settlement level up to now have centred around ICSDs and their mergers with, or acquisitions of, domestic CSDs. As previously explained, ICSDs are aiming to build on the significant experience they have in cross-border securities settlement through their dominance of settlement services in the international bonds market. With settlement links to many jurisdictions, ICSDs provide a convenient conduit for

[189] (European Commission 2004)

domestic CSDs to an established flow of business with investors already active in cross-border activities.

Euroclear, the ICSD with its roots in settlement services for Eurobond trading and based in Belgium and operating under Belgian jurisdiction, has acted as the nucleus around which the French (Sicovam), Dutch (Necigef), Belgian (CIK), and UK and Ireland (CREST) CSDs have consolidated. The intention of the Euroclear initiative is to eventually reach a point when settlement in all these jurisdictions can take place over a single integrated platform (which has been named by Euroclear the Single Platform), using similar – if not identical – processes, user interfaces, practices, and rules. In the first phase of the integration project, however, the individual CSDs would continue to interface with market participants through their own existing systems, but the Single Settlement Engine (SSE), developed as a single common settlement processor on which the final settlement algorithm that effects DvP runs, being used as common processor for the existing systems of the merged entities.

Another integration initiative has taken shape around Clearstream, the corporate entity formed out of a merger between Luxembourg-based ICSD Cedel International and Deutsche Börse Clearing in 1999. Clearstream International is the holding company for Clearstream Banking Luxembourg and Clearstream Banking Frankfurt, with Cedel International having been absorbed by the Clearstream Banking Luxembourg arm of the holding company (de Carvalho 2004). In addition to its international business, Clearstream also provides CSD services to the German and Luxembourg domestic markets, but once again, there is still an operational separation between the domestic and cross-border settlement arrangements provided by Clearstream, with the CASCADE platform developed to meet the requirements of the German domestic market and in Luxembourg operating LuxClear, the domestic CSD of Luxembourg. For international activity Clearstream operates its Creation platform offering a single entry point to a variety of markets (Clearstream International 2004).

Unlike Euroclear and Clearstream, the position of SIS-Sega, the Swiss CSD and ICSD, in the cross-border securities settlement landscape derives from the equities business, with SIS-Sega acting as the global custodian for the Swiss banking industry as well as a domestic CSD and clearinghouse (de Carvalho 2004).

In North America, despite the lack of fragmentation that characterises Europe and most of the rest of the world and the monopoly/utility status of the DTCC, the US CSD, there have been initiatives towards integrating cross-border securities settlement between the US and Canada. The DTCC has forged links with the Canadian Depository for Securities (CDS) the CDS having full access to US settlement for US and certain Canadian issues, book entry deliveries and depository services. In turn, CDS has three types of links into the US, all guaranteed by the CDS. In 1998, the DTC became a participant of CDS, completing the reciprocal step of creating an efficient two-way depository interface between the two entities. The DTC account at CDS, the first outside the US and approved by the SEC, replaced the physical movement of securities with book entry transfers and has increased the volume of southbound movements, and in turn has reduced the amount of failed trades, transaction costs and overall risk through certificate immobilization (STP Magazine 2000).

Other initiatives aiming to make cross-border settlement a practical reality through mergers and acquisitions is the one taking shape around the HEX-OM entity, itself formed out of the merger of the Finish exchange (HEX) and the Swedish trading technologies and clearing entity OM and which aims to bring about a single Nordic securities trading infrastructure.

References

Adams, S. and M. Berg (2004). "The nature of the Net: constructing reliability of health information on the web." Information technology & people **17**(2): 150-170.

Akrich, M. (1992). The De-Scription of Technical Objects. Shaping Technology/Building Society. W. E. Bijker and J. Law. Cambridge, Massachusetts (USA), MIT Press: 205-224.

Akrich, M. and B. Latour (1992). A Summary of a Convenient Vocabulary for the Semiotics of Human and Nonhuman Assemblies. Shaping Technology/Building Society. W. E. Bijker and J. Law. Cambridge, Mass, MIT Press: 259-264.

Allen, J. P. (2004). "Redefining the network: enrolment strategies in the PDA industry." Information technology & people **17**(2): 171-185.

Banking Federation of the European Union (1999). Remote access for collateral management: users' views on remote access for collateral management in the framework of monetary policy operations. Brussels, Banking Federation of the European Union: 1-10.

Barry, A. (2002). "The anti-political economy." Economy and society **31**(2): 268–284.

Barry, A. and D. Slater (2002). "Introduction: the technological economy." Economy and society **31**(2): 175-193.

Basel Committee on Banking Supervision (2004). Basel II: International Convergence of Capital Measurement and Capital Standards: a Revised Framework. Basel, Switzerland, Bank for International Settlements.

Benjamin, J. (1996). The law of global custody. London, Butterworths.

Benjamin, J. (1998). "Determining the situs of interests in immobilised securities." International and comparative law quarterly **47**(4): 923-934.

Benjamin, J. (2000). Interests in securities: a proprietary law analysis of the international securities markets. Oxford, UK, Oxford University Press.

Berger, A. N., R. DeYoung, H. Genay and G. F. Udell (1999). "Globalization of financial institutions: evidence from cross-border banking performance." Federal Reserve Bank of Chicago. Working Paper Series **No. WP-99-25**: 1-113.

Bernanke, B. S. (1990). "Clearing and settlement during the crash." Review of financial studies 3(1): 133-151.

Beunza, D., I. Hardie and D. MacKenzie (2006). "A price is a social thing: towards a material sociology of arbitrage." Organization studies **27**(5).

Blakey, G. G. (1993). The post-war history of the London stock market, 1945-92. Didcot, Oxfordshire, Mercury.

BNP Paribas Securities Services (2002). Contribution to the joint CESR/ECB consultation in the field of clearing and settlment. CESR/ECB. Brussels, European Central Bank: 1-32.

Bowker, G. C. (1994). Information Mythology and Infrastructure. Information acumen : the understanding and use of knowledge in modern business. L. Bud-Frierman. London ; New York, Routledge: 231-247.

Callon, M. (1998a). The embeddedness of economic markets in economics: Introduction. The Laws of the Markets. M. Callon. Oxford, Blackwell Publishers/The Sociological Review.

Callon, M. (1998b). The laws of the markets. Oxford, Blackwell Publishers/The Sociological Review.

Callon, M., A. Barry and D. Slater (2002). "Technology, politics and the market: an interview with Michel Callon." Economy and society **31**(2): 285-306.

Callon, M., Y. Millo and F. Muniesa, Eds. (2007). Market Devices. The Sociological Review Monographs. Oxford, UK, Blackwell.

Callon, M. and F. Muniesa (2005). "Economic markets as calculative collective devices." Organization studies **26**(8): 1229-1250.

Carruthers, B. G. and S. Babb (2000). Economy/society : markets, meanings, and social structure. Thousand Oaks, Calif. ; London, Pine Forge Press.

Cerny, P. G. (1994). "The dynamics of financial globalization: Technology, market structure, and policy response." Policy Sciences **27**(4): 319-342.

Chapman, A. B. (1990). International Securities Regulation in a Global Electronic Environment. Innovation and technology in the markets: a reordering of the world's capital market systems. D. R. Siegel. Chicago, Ill., Probus Pub. Co.: 197-208.

Clearstream International (2004). Products & Services, Clearstream International. **2004**.

Cohen, N. (2007). ECSDA cautions against European settlement system. Financial Times. London.

Committee on Payment and Settlement Systems (1992). Delivery versus Payment in Securities Settlement Systems. Basel, Bank for International Settlements: 1-37.

Committee on Payment and Settlement Systems (1995). Cross-border securities settlements. Basle, Switzerland, Bank for International Settlements: 1-92.

Committee on Payment and Settlement Systems (2000). The Contribution of Payment Systems to Financial Stability. Basel, Switzerland, Bank for International Settlements.

Committee on Payment and Settlement Systems (2001). Core Principles for Systemically Important Payment Systems. Basel, Switzerland, Bank for International Settlements.

Committee on Payment and Settlement Systems and Technical Committee of the International Organization of Securities Commissions (2001). Recommendations for securities settlement systems. Basel, Bank for International Settlements,
International Organization of Securities Commissions,: 1-45.

Cooren, F. (2004). "Textual Agency: How Texts Do Things in Organizational Settings." Organization **11**(3): 373-393.

CRESTCo (2002a). The Domestic Legal Framework. London: 1-99.

CRESTCo (2002b). Recommended proposal for the merger of CRESTCo Limited and Euroclear plc by way of a scheme of arrangement (under section 425 of the Companies Act 1985). London: 1-64.

CRESTCo (2004). Business Model implementation, CRESTCo. **2004**.

CRESTCo (2005). CREST Reference Manual. London: 1-341.

CRESTCo (2006). Enhancing CREST: Single Settlement Engine. London: 1-58.

Cross-border Market Advisory Committee (2005). Cross-border MAC Flash Report. Brussels, Euroclear: 1-4.

Currie, W. (1997). "Computerising the stock exchange: a comparison of two information systems." New technology, work and employment **12**(2): 75-83.

Currie, W. and L. P. Willcocks (1998). "Analysing four types of IT sourcing decisions in the context of scale, client/supplier interdependency and risk mitigation." Information Systems Journal **8**(2): 119-143.

de Carvalho, H., Cynthia (2004). Cross-Border Securities Clearing and Settlement Infrastructure in the European Union as a Pre-requisite to

Financial Markets Integration. HWWA Discussion Paper. Hamburg: 1-54.

Deutsche Borse Group and Clearstream International (2002). Cross-Border Equity Trading, Clearing, and Settlement in Europe. Frankfurt: 1-38.

Dickson, P. G. M. (1967). The financial revolution in England : a study in the development of public credit,1688-1756. London, Macmillan.

Downes, J. and J. E. Goodman (1998). Dictionary of finance and investment terms. Hauppauge, N.Y., Barron's Educational Series.

Drummond, H. (1996). Escalation in decision-making : the tragedy of Taurus. Oxford, UK, Oxford University Press.

Drummond, H. (1998). "Riding a tiger: some lessons of Taurus." Management Decision **36**(3): 141-146.

Duguid, C. (1901). The story of the Stock Exchange : its history and position. London, Grant Richards.

Euroclear (1999). Euroclear Board Announces Creation Of New European, Market-Owned Bank. Brussels.

Euroclear (2002). Delivering a domestic market for Europe. Brussels, Euroclear Bank: 1-42.

Euroclear (2003a). Business Plan for Systems Consolidation. Euroclear Business Model Implementation. Brussels: 1-25.

Euroclear (2003b). The Euroclear Business Model, further details - Edition 1. Euroclear Business Model Implementation. Brussels: 1-55.

Euroclear (2003c). Harmonisation Roadmap. Euroclear Business Model Implementation. Brussels: 1-25.

Euroclear (2003d). Overview and Planning - Edition 2. Euroclear Business Model Implementation. Brussels: 1-15.

Euroclear (2003e). The Single Settlement Engine and subsequent Business Model deliverables. Euroclear Business Model Implementation. Brussels: 1-43.

Euroclear (2004a). Common Communication Interface. Euroclear Business Model Implementation. Brussels: 1-33.

Euroclear (2004b). Euroclear accelerates platform-consolidation and market-practice harmonisation plans. Brussels.

Euroclear (2004c). Harmonisation Fundamentals. Euroclear Business Model Implementation. Brussels: 1-75.

Euroclear (2004d). Harmonisation Preliminary Proposals. Euroclear Business Model Implementation. Brussels: 1-57.

Euroclear (2005a). CREST Settlement Discipline: Overview of rules and common questions. London: 1-31.

Euroclear (2005b). Taking Stock. Brussels: 1-6.

Euroclear (2006a). Common Communications Interface - Service Description. Euroclear Business Model Implementation. Brussels: 1-80.

Euroclear (2006b). CREST and the SSE. SSE Clinic, London, Euroclear.

Euroclear (2006c). Glossary of terms relative to securities clearing, settlement and custody in Euroclear. Euroclear Business Model Implementation. Brussels: 1-133.

Euroclear (2007). Our vision : Delivering low-cost cross-border settlement, Euroclear. **2007**.

European Central Bank (2006). The Eurosystem is evaluating opportunities to provide settlement services for securities transactions. Frankfurt.

European Commission (2004). The Giovannini Group; Clearing and Settlement, European Commission,. **2004**.

Faraj, S., D. Kwon and S. Watts (2004). "Contested artifact: technology sensemaking, actor networks, and the shaping of the web browser." Information technology & people **17**(2): 186-209.

Fleming, M. J. and K. Garbade (2002). "When the Back Office Moved to the Front Burner: Settlement Fails in the Treasury Market After September 11." Economic Policy Review **8**(2).

Fligstein, N. (1996). "Markets as politics: A political-cultural approach to market institutions." American Sociological Review.

Fligstein, N. (1997). Markets, politics and globalization. Uppsala, Uppsala University.

Fligstein, N. (2001). The architecture of markets: an economic sociology of twenty-first century capitalist societies. Princeton, N.J., Princeton University Press.

Fligstein, N. and I. Mara-Drita (1996). "How to make a Market : Reflections on the attempt to create a Single Market in the European Union." The American Journal of Sociology **102**(1): 1-33.

Galison, P. L. (1987). How experiments end. Chicago, University of Chicago Press.

Galison, P. L. (1999). Trading Zone: coordinating action and belief. The Science Studies Reader. M. Biagioli. New York, Routledge: 137-160.

Giovannini Group (2001). Cross-border clearing and settlement arrangements in the European Union. Economic papers, No.163. Commission of the European Communities and Directorate-General for Economic and Financial Affairs. Brussels, European Commission Directorate-General for Economic and Financial Affairs: 88.

Giovannini Group (2003). Second Report on EU Clearing and Settlement Arrangements. Brussels, European Commission Directorate-General for Economic and Financial Affairs.

Godeffroy, J.-M. (2006). Ten frequently asked questions about TARGET2-Securities. British Bankers Association, London, European Central Bank.

Godeffroy, J.-M. (2007). Letter from Jean-Michel Godeffroy, Director General Payment Systems and Market Infrastructure of the European Central Bank to Joël Mérère, Chairman of the European Central Securities Depository Association. Frankfurt: 1-6.

Granovetter, M. (1985). "Economic Action and Social Structure: The Problem of Embeddedness." American Journal of Sociology **91**(3): 481-510.

Granovetter, M. S. and R. Swedberg (1992). The sociology of economic life. Boulder, Westview Press.

Grass, D. (2007). Move to delay EU securities system. Financial Times. London.

Group of Thirty (1988). Clearance and Settlement Systems in the World's Securities Markets. Washington, Group of Thirty: 87.

Group of Thirty (1990a). Clearance and Settlement Systems: Status Reports. Washington, Group of Thirty.

Group of Thirty (1990b). Presentations to the Group of Thirty Conference on Clearance and Settlement Systems. Clearance and Settlement Systems, London, Group of Thirty.

Group of Thirty (2003). Global Clearing and Settlement: A Plan of Action. Washington DC, USA: 156.

Guadamillas, M. and R. Keppler (2001). Securities Clearance and Settlement Systems: a guide to best practices. Washington, USA, The World Bank: 1-34.

Hanneman, R. A. (2001). Introduction to Social Network Methods. Riverside, USA, University of California.

Hanseth, O. (2002). From systems and tools to networks and infrastructures - from design to cultivation: Towards a theory of ICT solutions and its design methodology implications. Oslo.

Hanseth, O. (2003). From Systems and Tools to Networks and Infrastructures - from design to cultivation. Towards a theory of ICT solutions and its design methodology implications.

Hanseth, O., M. Aanestad and M. Berg (2004). "Actor-network theory and information systems. What's so special?" Information technology & people **17**(2): 116-123.

Hewlett-Packard Development Company (2002). CRESTCo. HP Case Studies: 1-4.

Hughes, T. P. (1983). Networks of power : electrification in Western society, 1880-1930. Baltimore, Johns Hopkins University Press.

Hughes, T. P. (1987). The Evolution of Large Technological Systems. The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology. W. E. Bijker, T. P. Hughes and T. J. Pinch. Cambridge, Mass., MIT Press: 51-82.

Interview C (2006). Senior Executive, Business Model and Harmonisation Division. London, Euroclear.

Interview D (2006). Former Chairman, Bank of England Settlement Taskforce. London.

Interview E (2006). Chairman, UK MAC. London, UK Market Advisory Committee.

Interview F (2006). Senior Executive, Business Model and Harmonisation Division. London, Euroclear.

Knorr-Cetina, K. (2005). How Are Global Markets Global? The Architecture of a Flow World. The Sociology of Financial Markets. K. Knorr Cetina and A. Preda. Oxford, UK, Oxford University Press.

Knorr-Cetina, K. and U. Bruegger (2002). "Global Microstructures: The Virtual Societies of Financial Markets." American Journal of Sociology **107**(4): 905-950.

Kynaston, D. T. A. (1983). The London Stock Exchange, 1870-1914 : an institutional history.

Lane, F. C., R. C. Mueller and American Council of Learned Societies. (1985). Money and banking in medieval and Renaissance Venice. Baltimore, Johns Hopkins University Press.

Lannoo, K. and M. Levin (2001). The Securities Settlement Industry in the EU Structure, Costs and the Way Forward. Brussels, Centre for European Policy Studies.

Latour, B. (1987). Science in action: how to follow scientists and engineers through society. Cambridge, Mass., Harvard University Press.

Latour, B. (1992). Where are the missing masses? The Sociology of a Few Mundane Artifacts. Shaping Technology/Building Society. W. E. Bijker and J. Law. Cambridge, Massachusetts, MIT Press: 225-258.

Latour, B. (1993). Pasteur on lactic acid yeast : a partial semiotic analysis.

Latour, B. (1996a). Aramis, or, The love of technology. Cambridge, Mass., Harvard University Press.

Latour, B. (1996b). "On actor-network theory. A few clarifications." Soziale Welt **47**(4): 369-381.

Latour, B. (1996c). On interobjectivity. The lessons of simian societies, Mind, Culture, and Activity.

Latour, B. (1999). Pandora's hope: essays on the reality of science studies. Cambridge, Massachusetts, Harvard University Press.

Latour, B. (2002). "Morality and technology: the end and the means." Theory, Culture, and Society **19**(5-6): 247-260.

Latour, B. (2004). On Using ANT for studying information systems - a (somewhat) Socratic Dialog. The social study of information and communication technology: innovation, actors and contexts. C. Avgerou, C. Ciborra and F. Land. Oxford, Oxford University Press: 290.

Latour, B. (2005). Reassembling the social : an introduction to actor-network-theory. Oxford ; New York, Oxford University Press.

Latour, B., P. Mauguin and G. v. Teil (1992). "A Note on Socio-Technical Graphs." Social Studies of Science **22**(1): 33-59.

Law, J. (1992). "Notes on the theory of the actor-network: ordering, strategy, and heterogeneity." Systems Practice **5**(4): 379-393.

Law, J. (2000). Objects, Space, and Others. Lancaster, Centre for Science Studies, Lancaster University: 1-13.

Lee, A. (2001). "Editorial." Management information systems quarterly **25**(1): iii-vii.

Lee, R. (1998). What is an exchange? The automation, management, and regulation of financial markets. Oxford ; New York, Oxford University Press.

Lepinay, V.-A. (2007). Decoding Finance: Articulation and Liquidity around a Trading Room. Do Economists Make Markets? On the Performativity of Economics. D. Mackenzie, F. Muniesa and L. Siu. Princeton, USA, Princeton University Press.

MacKenzie, D. (2005). "Opening the black boxes of global finance." Review of International Political Economy **12**(4): 555 - 576.

MacKenzie, D. and Y. Millo (2003). "Constructing a market, performing theory: the historical sociology of a financial derivatives exchange." American Journal of Sociology **109**: 107-145.

MacKenzie, D., F. Muniesa and L. Siu (2007). Do economists make markets? on the performativity of economics. Princeton, USA, Princeton University Press.

MacKenzie, D. A. (2006). An engine, not a camera : how financial models shape markets. Cambridge, Mass., MIT Press.

Mahring, M., J. Holmstrom, M. Keil and R. Montealegre (2004). "Trojan actor-networks and swift translation: bringing actor-network theory to IT project escalation studies." Information technology & people **17**(2): 210-238.

Marres, N. (2004). "Tracing the trajectories of issues, and their democratic deficits, on the web: the case of the Development Gateway and its doubles." Information technology & people **17**(2): 124-149.

Mérère, J. (2007). Letter from ECSDA to ECB on TARGET2-securities. Brussels: 1-6.

Michie, R. C. (1999). The London Stock Exchange: a history. Oxford, Oxford University Press.

Millo, Y., F. Muniesa, N. S. Panourgias and S. V. Scott (2005). "Organised detachment: Clearinghouse mechanisms in financial markets." Information & Organization **15**(3): 229-246.

Mirowski, P. (1981). "The Rise (and Retreat) of a Market: English Joint Stock Shares in the Eighteenth Century." Journal of Economic History **41**(3): 559.

Mirowski, P. (2007). "Markets come to bits: Evolution, computation and markomata in economic science." Journal of Economic Behavior & Organization **63**(2): 209-242.

Mol, A. and J. Law (1994). "Regions, networks, and fluids: anaemia and social topology." Social Studies of Science **24**(4): 641-671.

Moser, I. and J. Law (2006). "Fluids or flows? Information and qualculation in medical practice." Information technology & people **19**(1): 55-73.

Moser, J. T. (1998). Contracting Innovations and the Evolution of Clearing and Settlement Methods at Futures Exchanges. Working Paper Series. Chicago, Federal Bank of Chicago: 45.

Moser, J. T. (1999). Origins of the Modern Exchange Clearinghouse: A History of Early Clearing and Settlement Methods at Futures Exchanges. Chicago, Federal Reserve Bank of Chicago.

Muniesa, F. (2000). "A Walrasian robot: exchange automation and the accuracy of price discovery." Politix **13**(52): 121-156.

Muniesa, F. (2002). Reserved anonymity : on the use of telephones in the trading room.

Muniesa, F. (2004). "Assemblage of a market mechanism." Journal of the centre for information studies **5**(3): 11-19.

Muniesa, F. (2007). "Market technologies and the pragmatics of prices." Economy and society **36**(3): 377-395.

North, D. C. (1977). "Markets and other allocation systems in history: the challenge of Karl Polanyi." Journal of European Economic History **6**: 703-716.

Padgett, J. F. (2001). Organizational Genesis, Identity and Control: The Transformation of Banking in Renaissance Florence. Networks and Markets. E. Rauch James and A. Casella. New York, Sage: 211-257.

Padgett, J. F. and C. K. Ansell (1993). "Robust action and the rise of the Medici, 1400-1434." American Journal of Sociology **98**: 1259-1319.

Pinch, T. J. and W. E. Bijker (1987). The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other. The Social construction of technological systems : new directions in the sociology and history of technology. W. E. Bijker, T. P. Hughes and T. J. Pinch. Cambridge, Mass., MIT Press: 17-51.

Pirrong, C. (2002). "Securities market macrostructure: property rights and the efficiency of securities trading." Journal of Law, Economics, and Organisation **18**(2): 385-410.

Preda, A. (2002). "Financial knowledge, documents, and the structures of financial activities." Journal of contemporary ethnography **31**(2): 207-239.

Rauch, J. E. and A. Casella (2001). Networks and markets. New York ; [Great Britain], Russell Sage Foundation.

Rosenbaum, E. F. (2000). "What is a Market? On the Methodology of a Contested Concept." Review of Social Economy **LVIII**(4): 455-481.

Sassen, S. (2005). The Embeddedness of Electronic Markets: The Case of Global Capital Markets. The sociology of financial markets. K. Knorr-Cetina. Oxford, UK, Oxford University Press: 17-37.

Schwarcz, S. L. and J. Benjamin (2002). "Intermediary Risk In The Indirect Holding System For Securities." Duke Journal Of Comparative & International Law **12**: 309-330.

Shearlock, P. and W. Ellington (1994). The Eurobond Diaries. Brussels, Euroclear Clearance Systems.

Skinner, C. (2007). The quest for alpha, Finextra. **2007**.

Slater, D. (2002). "From calculation to alienation: disentangling economic abstractions." Economy and society **31**(2): 234-249.

Smith, B. (1996). "CREST: its recognition and approval." Financial Stability Review(1): 51-57.

Sommer, J., H. (2001). "International Securities Holding and Transfer Law." Arizona Journal of International and Competitive Law **18**(2): 685-698.

Star, S. L. and J. R. Griesemer (1989). "Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39." Social Studies of Science **19**(3): 387-420.

Star, S. L. and K. Ruhleder (1996). "Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces." Information Systems Research **7**(1): 111-134.

STP Magazine (2000). Take your partner. STP Magazine.

Thompson, G., J. Frances, R. Levacic and M. Jeremy, Eds. (1991). Markets, hierarchies, and networks: the coordination of social life. London, Sage Publications.

Thrift, N. J. (1994a). On the Social and Cultural Determinants of International Financial Centres: the Case of the City of London. Money/space: geographies of monetary transformation. S. Corbridge, R. L. Martin and N. J. Thrift. Oxford, UK, Blackwell: 327-355.

Thrift, N. J. (1994b). "A phantom state? The de-traditionalization of money, the international financial system and international financial centres." Political Geography **13**(4): 299-327.

Thrift, N. J. (1996). "New Urban Eras and Old Technological Fears: Reconfiguring the Goodwill of Electronic Things." Urban Studies **33**(8): 1469-1493.

Thrift, N. J. (2004). "Remembering the technological unconscious by foregrounding knowledges of position." Environment and Planning D: Society and Space **22**: 175-190.

White, H. C. (1981). "Where do markets come from?" American Journal of Sociology **87**(3): 517-547.

White, H. C. (2002). Markets from networks: Socioeconomc models of production. Princeton, Princeton University Press.

Willcocks, L. P. and J. Hindle (2004). From the Eye of the Market 1. London, Knowldge Capital Partners Ltd: 1-48.

Williams, J. (1986). The economic function of futures markets. Cambridge, Cambridge University Press.

Williams, R. and D. Edge (1996). "The social shaping of technology." Research Policy **25**: 856-899.

Winner, L. (1980). "Do artifacts have politics." Daedalus ; Vol/Issue: 109:1: Pages: 121-136.

Winner, L. (1993). "Upon Opening the Black Box and Finding it Empty: Social Constructivism and the Philosophy of Technology." Science, technology, and Human Values **18**(3): 362-378.